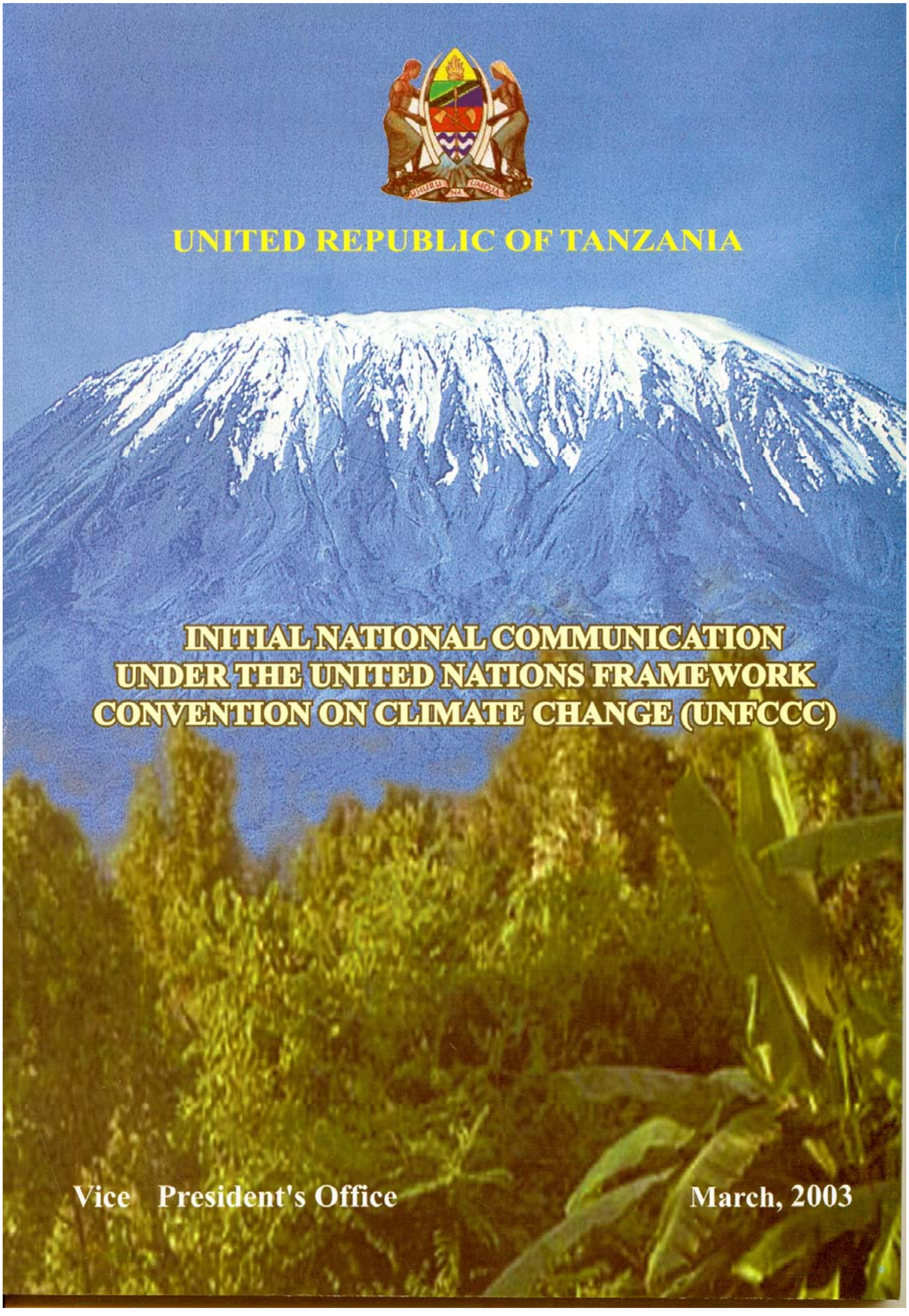

UNITED REPUBLIC OF TANZANIA

INITIAL NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

Vice President's Office

March, 2003

UNITED REPUBLIC OF TANZANIA
VICE PRESIDENT'S OFFICE

INITIAL NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

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List of Acronyms

ACMAD	- Africa Centre for Meteorological Applications for Development
BIS	- Basic Industrial Strategy
CEEST	- Centre for Energy, Environment, Science and Technology
CH4	- Methane
CBM	- Community Based Management
CLIPS	- Climate Information and Prediction Service
COP	- Conference of the Parties
CO2	- Carbon dioxide
CO	- Carbon monoxide
CCCM	- Canadian Climate Change Model
DANIDA	- Danish International Development Agency
DOE	- Division of Environment
DOM	- Directorate of Meteorology
DM	- Dry matter
DMC	- Drought Monitoring Centre
ECMWF	- European Centre for Medium Range Weather Forecasting
FAO	- Food and Agricultural Organization
GCA	- Game Controlled Area
GEF	- Global Environment Facility
GFD	- Global Fluid Dynamics
GDP	- Gross Domestic Product
GTZ	- Deutsche Gesellschaft fur Technisch Zusammenarbeit
GISS	- Godad Institute of Space Science
GHG	- Greenhouse Gas
GWP	- Global Warming Potential
GCM	- Global Circulation Model
GR	- Game Reserve
IDRC	- International Development Research Council - Canada
IEA	- International Energy Agency
IDO	- Industrial Diesel Oil
IPCC	- Intergovernmental Panel on Climate Change
HIS	- Habitat Suitability Index
MEM	- Ministry of Energy and Minerals
MOA	- Ministry of Agriculture
NAP	- National Action Plan
NCAA	- Ngorongoro Conservation Authority Area
NCCST	- National Climate Change Study Team
NCCSC	- National Climate Change Steering Committee
NEMC	- National Environment Management Council
NMVOC	- Non-Methane Volatile Organic Commands
NP	- National Park
NO	- Nitrogen oxide
OECD	- Organization of Economic Cooperation and Development
TAFORI	- Tanzania Forestry Research Institute

TANESCO	- Tanzania Electric Supply Company Limited
TPDC	- Tanzania Petroleum Development Corporation
TMA	- Tanzania Meteorological Authority
TIRDO	- Tanzania Industrial Research and Development Organization
UNFCCC	- United Nations Framework Convention on Climate Change
UNEP	- United Nations Environment Programme
UKMO	- United Kingdom Meteorological Organization
USCSP	- United States Country Studies Programme
UNCCEE	- UNEP Collaborating Centre for Energy and Environment
WMO	- World Meteorological Organization
WCASP	- World Climate Applications and Services Programme

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ACKNOWLEDGEMENT

The massive injection of greenhouse gases into the atmosphere has resulted in an imbalance in its radiation forces. Observations reveal that the earth is getting warmer and the mean global temperature keeps on rising annually. The Heads of States and Governments signed the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in 1992, in Rio de Janeiro, Brazil, in a bid to combat the global warming phenomenon.

The Framework Convention on Climate Change came into force in March 1994. According to Articles 4 and 12 of the Convention, Parties are required to submit their Initial National Communication, which should include a national inventory of sources of greenhouse gases and their removal by sinks, identification of vulnerable sectors and actions to be taken for sustainable future socio-economic developments without a further increase in the emissions of greenhouse gases.

Climate change is recognized as a global problem. Therefore, it is imperative for nations to view the world's climate in broad cooperative perspectives to fully understand its nature and behaviour, and to predict its future course. Accordingly, international climate programmes and exchange of knowledge among scientists should be encouraged. Predicting future climate well ahead can help to improve decision making in a wide range of activities. More important is perhaps the widely accepted precautionary principle of 'taking measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects.'

In August 1997, the Global Environment Facility (GEF), through its Enabling Activities Programme implemented by UNEP provided financial and technical support to enable Tanzania to prepare her Initial National Communication, which was completed in September 1999. The government of the United Republic of Tanzania would like to take this opportunity to convey special thanks to the Global Environment Facility (GEF), which provided funding for the climate change studies on which this Initial National Communication has been compiled and to the Implementing Agency of the United Nations Environment Programme. In particular, many thanks go to Dr. Pak Sum Low and Dr. Ravi Sharma, both of UNEP, who played a pivotal role in the drafting of the project proposal, and for providing technical guidance and administrative support respectively.

The Government of Tanzania also wishes to gratefully acknowledge the support of the following agencies: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) of Germany, United States Country Studies Programme (USCSP), International Development Research Centre (IDRC) of Canada, Danish International Development Agency (DANIDA) and the UNEP Collaborating Centre for Energy and Environment (UCCEE) of Denmark. Their assistance was instrumental in the implementation of several climate change studies upon which this national communication is based.

Further, the government of Tanzania wishes to acknowledge the invaluable contributions and inputs into various parts of the national climate change studies that were made either directly or indirectly by various institutions and governmental agencies. Special gratitude is extended to members of the National Climate Change Study Team (NCCST) who worked tirelessly in the preparation of the various sectoral reports, CEEST for coordination and provision of the secretariat to national climate change study team and the National Climate Change Steering Committee (NCCSC) for the overall supervision of the climate change studies in the country, which made this communication possible.

Raphael O. S. Mollel
Permanent Secretary, Vice President's Office
and Focal Point for the UNFCCC and GEF

FOREWORD

In 1988, The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC), whose mandate was to assess the available scientific information and the environment and socio-economic impacts of climate change, and to formulate response strategies to the same. The United Nations (UN), on the 27th January 1989 adopted the IPCC through resolution A/RES/43/53 of the General Assembly. The IPCC submitted its First Assessment report to the Second World Climate Conference in August 1990, and this Report served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC). Tanzania along with over 150 other countries signed the Convention at the Earth Summit in Rio de Janeiro, Brazil, in June 1992. It subsequently ratified the same in March 1996.

As the IPCC reports indicate, climate change is not a myth anymore, or a subject of controversy. It is a reality that has to be addressed to ensure sustainability of existence, not only for the present but also for the future generations. Tanzania, like the rest of the international community, is conscious of the serious consequences of climate change, and fully supports the ultimate objective of the UNFCCC, which is "to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

In pursuit of her commitment under the Convention, Tanzania has been undertaking climate change studies since 1993. This communication presents a summary of achievements so far gained in this painstaking exercise. The Division of Environment under the Vice President's Office coordinates the national climate change studies in Tanzania. The studies are the product of a collective commitment by government agencies, the private sector, and non-government organizations. Although some of the analyses are riddled with uncertainties due to the nature of the models applied, and a lot of proposed actions for reducing the same are still on the drawing boards, the communication also represents a major benchmark in Tanzania's endeavours to join the international community in combating the fundamental causes of instability in the climate systems and their negative impacts.

Tanzania has been a keen participant in various fora on climate change. In 1997 it played a pivotal role in the negotiations that led to the adoption of the Kyoto Protocol. In that year, Tanzania chaired the Group of 77 and China spoke for the Group. By submitting this communication, Tanzania wishes to demonstrate her unreserved will and desire to meet international obligations under the UNFCCC.

It is my hope that this report will demonstrate the willingness of the Tanzanian Government to take the threat of global warming seriously and to implement the measures required. It is indeed a singular and great pleasure for me to present, on behalf of the United Republic of Tanzania, the Initial National Communication of Tanzania to the UNFCCC Secretariat for onward transmission to the Conference of the Parties. This document, which is a product of a collective effort of development practitioners in the country, will also serve as a cardinal step in the planning and evaluation of future development programmes.

Hon. Arcado D. Ntagazwa (MP)
Minister of State-Environment, Vice President's Office

EXECUTIVE SUMMARY

A) INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC) to which Tanzania is a signatory, requires countries that ratify the Convention to communicate to the Conference of Parties (CoP) information regarding human induced emissions by sources and removal by sinks of greenhouse gases. The communication should also include technological and policy options for mitigation of greenhouse gas emissions as well as assessment of vulnerability and adaptation to climate change impacts.

In order to prepare this communication, and with the benefit of grants from the United Nations Environment Programme (UNEP), an enabling environment for the Initial National Communication Project was implemented. Other external support agencies supported various climate change studies in Tanzania, which was an important input into this communication.

The implementation of the study followed the guidelines based on methodologies developed by UNEP, the Organization of Economic Cooperation and Development (OECD), US Country Studies Programme and the Intergovernmental Panel on Climate Change (IPCC).

B) NATIONAL CIRCUMSTANCES

The United Republic of Tanzania lies south of the Equator between latitudes 1^0S and 12^0S, and between longitudes 30^0E and 41^0E. It is located between the Great Lakes of Victoria, Tanganyika and Nyasa. It shares borders with Kenya to the North, Uganda, Rwanda and Burundi to the Northwest, the Democratic Republic of Congo to the West, Zambia, to the Southwest, and Malawi and Mozambique to the South.

The total area is 945,000 square kilometres with the Mainland covering 939,702 square kilometers. The land area of the mainland is 881,289 square kilometers while 58,413 square kilometers are inland lakes. The available land for cultivation is 40 million hectares and cultivated land is about 5.2 square kilometers. Forests and woodland occupy 50 percent of the total area and 25 percent is wildlife reserves and national parks. The coastline extends 800 kilometers from 4^0S to 10^0S. Except for the coastal belt most of the country is part of the Central African plateau lying between 1,000 to 3,000 meters above sea level.

The country has a great diversity of climatic conditions with annual mean temperature ranging from a mean daily temperature of between 24^oC - 34^oC. Within the plateau, mean daily temperatures range between 21^oC - 24^oC while in the highland areas temperatures range from 15^{o}C - 20^{o}C. The country experiences a mean annual rainfall varying from below 500 mm to over 2500 mm annually, largely depending on altitude. Rainfall in Tanzania is of two regimes. Some parts of the country receive bimodal rainfall, long rains during the months of March to May and short rains during the months of October to December. Other parts experience a unimodal rainfall pattern whereby most of the seasonal rainfall is during the months of December to April. In both patterns there is a long dry season from May to October. The hottest months are December to February and the coolest months are June to August.

For the last five years the Gross Domestic Product (GDP) has been growing at an average rate of 4 percent per annum with the population growth rate being 2.8 percent per annum. Agriculture contributes 49.6 percent of the GDP, whereas 8.1 percent comes from the manufacturing industry, 1.3 percent from mining and quarrying. The share of services sector to the GDP is 36.4 percent and construction sector is 4.6 percent. Estimated share of the informal sector to the GDP is 32 percent. In 1994 Tanzania had an estimated population of 26.7 million, and 18 percent of the population lives in urban areas. Tanzania is ranked as one of the poorest countries in the world, with per capita income of USD 156.1 per year for the year 1994. The extent of poverty among Tanzanians is high. It is estimated that 48 percent of Tanzanians live in poverty condition, while 36 percent live in very poor conditions. Average earnings do not meet requirements for basic minimum needs.

The energy sector covers the non-commercial primary energy sources (mainly wood-fuels) and commercial energy (petroleum, natural gas, hydroelectricity, coal and some geothermal energy sources). Both Tanzania's energy supply and end use structure reflect her low level of development. Biomass-based fuel accounts for 92 percent of the total energy consumption and the rest is mainly petroleum and hydroelectricity. The country has considerable biomass resources in the form of wood and agricultural residues. There is a possibility of converting these resources into electricity and energy for industrial and domestic purposes in future.

C) NATIONAL INVENTORIES OF GREENHOUSE GAS EMISSIONS AND REMOVALS

The base year for the development of the inventory of greenhouse gas (GHG) emissions and removals in Tanzania was 1990. IPCC guidelines of 1991 were used in creating the inventory. The inventory was created for both direct GHGs such as Carbon Dioxide (CO_2,) Methane (CH_4), and Nitrous Oxide (N_2O), and indirect GHGs such as Nitrogen Oxides (NO_x) and Carbon Monoxide (CO). Major sectors addressed in the inventory were energy, agriculture, industrial process, waste management, and forestry and land use.

The activity data used was based on collected information and statistical data where available. The availability of activity data was hampered by lack of updated/continuously-collected information in most of the sectors. Limited surveys were undertaken to assist in updating the available information and data. A number of assumptions have been used to arrive at the sectoral emission levels. Where records were not available default data developed by International Energy Agency (IEA), Organisation for Economic Cooperation and Development (OECD), the Food and Agricultural Organization (FAO), and the Intergovernmental Panel on Climate Change (IPCC) were used. Emission factors based on IPCC guidelines have been applied except for the estimation of methane emissions from municipal wastewater treatment.

CO_2 estimates from international banker fuels were excluded in the 1990 inventory studies. Also the estimates of CO_2 emissions from biomass fuels or biofuels were excluded from the national inventory of GHGs emission and removal in studies because these are assumed to be part of the natural carbon cycle.

In order to calculate the Global Warming Potential (GWP) index for direct GHGs, the 1996 IPCC GWP was applied with a 100-year-time-horizon GWP index.

D) TECHNOLOGICAL AND OTHER OPTIONS FOR GREENHOUSE GAS MITIGATION

A number of technological and other options for the mitigation of greenhouse gases in Tanzania have been identified in various sectors including energy, forestry and land-use, agriculture and livestock, industry, household energy use and transport. Mitigation options identified are technological and non-technological. Non-technological options include such interventions as policy and behavioural changes.

The mitigation study involved the analysis of both economic and technological development. A macroeconomic analysis was carried out to develop the baseline and the mitigation scenarios. The analysis also involved identification and ranking of the mitigation options so as to enable planners prioritise the various options available in the menu.

E) POLICIES AND MEASURES

Several policies and measures which can assist in the implementation of GHG mitigation options as well as the adaptation of response measures to the climate change impacts, are in place in Tanzania. These are included in both the macro-economic policy and sectoral policies. The long term Tanzania Development Vision to the year 2025 is another important basis for the implementation of such options. The on-going economic policy and sectoral reforms also form a good basis for the implementation of Climate Change Action Plan. The National Environmental Policy of 1997 serves as the framework for implementing both the adaptation responses and mitigation measures.

Some measures that influence reduction in GHG emissions are already being undertaken. These measures target other development goals such as energy efficiency and conservation, and revenue collection. Various sectoral initiatives have implicitly addressed environmental concerns, notably the reduction in GHG emissions. Efforts are being made to ensure that climate change aspects are incorporated in development policies.

F) IMPACT OF CLIMATE CHANGE AND VULNERABILITY ASSESSMENT

In 1994 the Government of United States of America through the US Country Studies Programme supported a study on the assessment of vulnerability and adaptation response options for Tanzania. This study was completed in 1997 and the results were published in December 1998. The main consequences, predicted by using the Global Climate Change Scenarios, include a rise in the mean daily temperature, on average, by $3^{o}C$ - $5^{o}C$ throughout the country, and a rise in the mean annual temperature on average by $2^{o}C$ - $4^{o}C$. The results also indicate that there will be an increase in rainfall in some parts while other parts will experience decreased rainfall. Areas with a bimodal rainfall pattern will have increased rainfall ranging from 5 percent to 45 percent. Areas receiving unimodal rainfall will experience reduced rainfall ranging from 5 to 15 percent.

As a result of these changes several sectors will become vulnerable. These sectors include agriculture, water resources, forestry, grasslands, livestock, coastal resources and wildlife and biodiversity. The runoff of three major rivers will be altered. In rivers Pangani and Ruvu, runoff would decrease by 6 to 10 percent while in the Rufiji River runoff will increase by 5 to 11 percent. These changes would adversely affect water supply and socio-economic activities.

With respect to agriculture in areas where rainfall will increase, the leaching of nutrients, the washing away of the topsoil and water logging will affect plant development and yield. Climate change favours the occurrence of disease and pests due to the higher temperatures and increased rainfall.

Coffee will most likely be grown successfully where rainfall would increase. Cotton growing areas would be reduced. Maize yield will be reduced by about 33 percent over the entire country. These are some of the impacts on water resources and crop production. Impacts on the other sectors are also discussed.

In areas that will get less rainfall, irrigation will be required to substitute for moisture losses due to increased evapo-transpiration. Drought resistant crop varieties will be required. Under such conditions irrigation will most likely tend to be expensive because of reduced river runoff and the vulnerability of shallow wells necessitating the development of deep wells instead.

G) RESEARCH AND SYSTEMATIC OBSERVATIONS

Basic research on climate related issues is being carried out at the University of Dar es Salaam, the Sokoine University of Agriculture, Tanzania Forestry Research Institute (TAFORI), Mweka Wildlife College and Agricultural Research Institutes. The research is undertaken as part of normal scholarly activities and not necessarily for climate change. There is need to relate such research on subjects in energy, botany, atmospheric chemistry, physics, land degradation, forestry and others, to on going work on climate change under the UNFCCC.

There are several stations for monitoring atmospheric chemistry for meteorological purposes. Equipment for monitoring greenhouse gases and its related impacts to the atmosphere is not available in Tanzania. Sub-regional/regional arrangement to install a global climate change observation system would be very helpful in acquiring representative data and information. At present much of the data and information used in the climate change studies is obtained from Europe, the United States or Canada.

H CLIMATE CHANGE IMPLEMENTATION STRATEGIES

Institutional Framework

Institutional framework for climate change issues should take into account the need for exploitation of sector synergies. Article 4 paragraph one, sub-paragraph (c) of the UNFCCC states:

> …To promote and cooperate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including energy, transport, industry, agriculture, forestry and waste management sectors.

Therefore, specific projects for the exploitation of sector synergies in on-going projects in the relevant sectors, especially the energy sector, for facilitation of learning by doing are necessary. In Tanzania climate change studies have been organized in such a way that the relevant institutions responsible for the covered sectors are involved in one way or another. The institutions, which are the main players in this respect include: the Vice President's Office, Division of Environment; the Tanzania Meteorological Agency; the Department of Energy; Ministry of Industries and Trade; Ministry of Agriculture, Ministry of Natural Resources and Tourism, Department of Forestry and the centres of excellence representing non-governmental institutions. The National Climate Change Steering Committee under the chair of the Division of Environment and secretarialship of CEEST plays a major leading role.

Financial and Technological Constraints and Needs

The main challenge facing Tanzania is the need to balance accelerated economic growth with a more efficient management of the environment and the use of natural resources to ensure sustainability and address the issue of climate change. Substantial consessional financial and technical assistance is imperative, taking into account the magnitude of the institutional shortcomings and structural constraints faced by the Tanzanian economy. Assistance is also needed for training, research, sensitization and technological development and diffusion. There is need to strengthen the national capacity to manage technological changes.

Education, Training and Public Awareness

The training of experts has been undertaken in the process of carrying out the climate change studies. A training programme specific for building capacity in the relevant sectors would need to be initiated. At present, environmental issues are incorporated in the curricula of lower, tertiary and higher learning institutions. It is important to review the curricula of these institutions to ensure that the science of climate change is accommodated.

Public awareness on climate change, its impacts and responses is still very low. Climate variability goes unnoticed, as people do not differentiate between normal and induced climate variability and change. A comprehensive awareness programme is planned in order to make different interest groups/stakeholders aware of climate change impacts, their causes and the adaptation response options. Support for these endeavours by developed country Parties and by the Convention process will be required.

Stakeholders' workshops on climate change issues were also undertaken as one way of raising public awareness and receiving stakeholders' opinion, which also was instrumental in getting views from the stakeholders.

1: INTRODUCTION

1.1 BACKGROUND

The United Nations Framework Convention on Climate Change (UNFCCC) to which Tanzania is a signatory requires countries that ratify the Convention to communicate to the Conference of Parties (CoP) to the Convention information regarding human indicated emissions by sources and removal by sinks of greenhouse gases. The communication should also include technological and policy options for GHG mitigation as well as assessment of vulnerability and adaptation to climate change impacts. Tanzania ratified the UNFCCC on 17 April 1996, and therefore is committed to fulfilling its obligation under the Convention.

In order to prepare this communication, and with the benefit of grants from the United Nations Environment Programme (UNEP) an Enabling Environment for the Initial National Communication Project was implemented. Other External Support Agencies supported various climate change studies in Tanzania, which were important inputs into this communication. These include the Global Environment Facility (GEF), United Nations Environment Programme (UNEP), Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) of Germany, United States Country Studies Programme (USCSP), International Development Research Centre (IDRC) of Canada, Danish International Development Agency (DANIDA) UNEP Collaborating Centre for Energy and Environment (UCCEE). A team of researchers was organized under the auspices of the Centre for Energy, Environment, Science and Technology (CEEST). CEEST is a Dar es Salaam-based non-governmental organization that undertakes research and various studies related to energy, the environment, technology and science, water and sanitation, and natural resource use and management.

The implementation of the study followed the guidelines based on methodologies developed by UNEP, the Organization of Economic Cooperation and Development (OECD) and the Intergovernmental Panel on Climate Change (IPCC).

A National Steering Committee oversaw and gave guidance on the implementation of the study. The Committee members were drawn from Division of Environment (DoE), Directorate of Meteorology (DoM), National Environmental Management Council (NEMC), Ministry of Energy and Minerals (MEM), Ministry of Agriculture (MoA) Ministry of Industries and Trade, the Division of Forestry and Beekeeping, the University of Dar es Salaam, and CEEST.

1.2 NATIONAL CIRCUMSTANCES

1.2.1 Physiography

The United Republic of Tanzania is located on the east coast of Africa between parallels 1^0S and 12^0S and meridians 30^0E and 40^0E. It extends from Lake Tanganyika in the west, to the Indian Ocean in the east, Lake Victoria in the north, to Lake Nyasa and River Ruvuma in the south. It borders Kenya and Uganda in the north, Rwanda and Burundi in the northwest, the Democratic Republic of Congo to the west, Zambia to the southwest and Malawi and Mozambique to the south. Tanzania was formed by the union of Tanganyika (Mainland) and the Islands of Zanzibar and Pemba in 1964.

Mainland Tanzania has an area of about 939,702 square kilometres and the islands of Zanzibar and Pemba, in the Indian Ocean, occupy an area of 2,643 square kilometres. The mean annual rainfall varies from 500 millimeters to 2,500 millimetres and above. The average duration of the dry season is 5 to 6 months.

The United Republic of Tanzania has both the highest and lowest places in Africa: Mount Kilimanjaro summit at 5,958 metres above sea level and the floor of Lake Tanganyika at 356 metres below sea level respectively. Except for the coastal belt, most of the country is part of the central African plateau at between 1,000-3,000 metres above sea level, characterized by gently sloping plains and plateaus broken by scattered hills and low lying wetlands.

1.2.2 Climate

The country can be roughly divided into four main climatic/topological zones. Also Mainland Tanzania is intersected by the Rift Valley, with both the western and eastern wings cutting across the country. This is a geo-physically active area:

(a) ***The Lowland Coastal Zone***

This zone can further be divided into three sub-zones: the wet sub-zone, between 0 to 500 metres of elevation, with 1,800 millimetres of annual rainfall on average; humid sub-zone, elevation ranging from 500 metres to 1000 metres with an annual rainfall of between 1000 and 1,800 millimetres; and the drier zone, about 1,000 metres in altitude, with less than 1,000 millimetres of rainfall per annum.

(b) ***The Highlands Zone***

This comprises of the Northeastern Highlands, which include the Usambara Mountains, Mt. Kilimanjaro and Mt. Meru; the Southern Highlands, which include Mt. Rungwe, Livingstone ranges, and Mt. Mbeya. As catchment areas, these are generally areas of high precipitation.

(c***) The Plateau Zone***

Found around Lake Victoria and much of western Tanzania, this zone is occupied by what are generally referred to as m*iombo* woodlands. These are, in the main, dry areas with an average rainfall of up to 1,000 millimetres.

(d***) The Semi-desert Zone***

Mainly found in central and North Eastern Tanzania around Dodoma, Shinyanga, Arusha, Mwanza and Mara. The zone has a rainfall of less than 600 millimeters per annum.

1.2.3 The Economy

Over the last five years, the Gross Domestic Product (GDP) in constant prices has been growing at an average of 4 percent per annum with population growing at 2.8 percent a year. Agriculture is by far the single most important sector in the economy, growing at about 3 percent per annum, accounting for 49.6 percent of the GDP, and employing 80 percent of the active population work force and 75 percent of foreign exchange earnings. Agriculture is the main source of food supply and raw materials for the national industries with manufacturing contributing about 8.1 percent of the real GDP; mining and quarrying contributes about 1.3 percent of the real GDP. The transport sector accounts for about 6 percent of the real GDP and 16 percent of the gross capital formation.

1.2.4 Social Profile

In 1994, Tanzania had an estimated population of 26 million people. The population is estimated to be growing at the average rate of 2.8 percent per annum. The fertility rate is about 6.2 children per woman. About 46 percent of the population is under 15 years. Population in the age group of 15-64 years (the productive age) accounts for 50.23 percent of the total while the aged, 65 years and above account for 4.53 percent. Females account for 51.5 percent while males account for the remaining 48.5 percent of the total population. Females in the productive age (15-64 years) account for 51.3 percent of the population. The average population density is about 26 persons per square kilometre. About 25 percent of the total population lives in urban areas.

Households in Tanzania get their incomes mainly from self-employment on farm and non-farm activities, wage employment and rental services. The relative importance of the various sources of income indicate that 54 percent of rural households get their incomes from agricultural activities, 20 percent from non-agricultural self-employment activities and 8 percent from wage employment and 18 percent from other sources. About 28 percent of urban households get their incomes from agricultural activities, another 28 percent from self-employment in non-agricultural activities, 18 percent from wage employment, 2 percent from rent income, and 26 percent from other sources.

Life expectancy at birth is about 49 years for the year 1994. Infant mortality rate is about 88 per 1000 while the maternal mortality rate is about 529 per 100,000 and under five mortality rates are about 137 per 1,000. Total and severe malnutrition had declined from 50 percent in the 1980s to 30 percent in the late 1990s while severe malnutrition had declined from 6 percent to 2 percent during the same period. In terms of coverage, only 72 percent of the population lived within 5 kilometres from the nearest health facility. About 50 percent of 22 million rural population and 68 percent out of 4 million urban populations have access to improved water supply. Sanitation services are available to about 79 percent of the rural population and 85 percent of the urban population.

The literacy rate is about 84 percent. Gross enrolment in primary education is about 80 percent while that of secondary education is about 15 percent. Gender-wise, enrolment at the primary school level is around 50 percent for girls and 50 percent for boys while at the secondary school level, the percentage of girls is slightly lower.

Table 1.1: *Tanzania, National Circumstances*

CRITERIA	1990	1994	1996	1998
Population (Million people)	24	26.7	28.2	30
Relevant areas ('000 square kilometres)	945	945	945	945
Inland water area ('000 square kilometres)	61.5	61.5	61.5	61.5
GDP (1994 US$) at current price	2,880	4,170.6	5,952.7	7,710.7
GDP per capita (US$)	120	156.1	210.6	256.8
Estimated share of the informal sector in the economy in GDP (percentage) [1]	32	32	32	32
Share of industry in GDP (percentage)	8.0	8.1	8.0	8.4
Share of services in GDP (percentage) [2]	34.6	36.4	36.1	36.0
Share of agriculture in GDP (percentage)	47.8	49.6	50.6	49.1
Share of mining and Quarrying in GDP (percentage)	0.6	1.3	1.5	2.0
Share of construction in GDP (percentage)	3.2	4.6	3.9	4.3
Land area used for agricultural purposes (square kilometres)	5.2	5.2	5.2	5.2
Urban population as percentage of total population [3]	18	18	18	18
Grazing land (million hectares)	35	35.0	35	35
Other land (million hectares)	4.4	4.4	4.4	4.4
Livestock population (Million)*				
Cattle	13.046	13.461	15.957	16.602
Goats	8.529	9.72	10.36	11.3
(Annual average) Poultry	27.0	27.0	27	27
Forest area and woodlands (square kilometres)	44.0	44.0	44.0	44.0
Population in absolute poverty (percentage) [4]	48	48	48	48
Life expectancy at birth (years)	49	49	52	52
Literacy rate (percentage) [5]	84	84	84	84

Notes:

[1] Based on the Tanzania informal sector survey of 1991
[2] Includes electricity and water, trade, hotels and restaurants, financial and business services, public administration and other services, less financial services indirectly measured
[3] Based on National Population Census
[4] Based on Household Budget Survey of 1991/92
[5] based on Basic Statistics in Education
* Ministry of Agriculture and Food
Economic Surveys (1999)

1.2.5 Poverty Situation in Tanzania

Since independence in 1961, the Government of Tanzania has been preoccupied with three development problems: ignorance, diseases and poverty. National efforts to tackle these problems were initially channeled through centrally directed, medium-term and long-term development plan, and resulted in a significant improvement in per capita income and access to education, health and other social services until 1970s. Thereafter, these gains could not be sustained because of various domestic and external shocks, and policy weaknesses.

Today, after more than 30 years since declaring the war, against poverty, Tanzania is still ranked as one of the poorest countries in the world. For instance, per capita income of a Tanzanian is USD 156.1 per year for the year 1994. The extent of poverty among Tanzanians is still high. It is estimated that 48 percent of Tanzanians live under the poverty line, while 36% live in very poor conditions. Average earnings do not meet requirements for basic minimum needs. To many, a single meal in a day is commonplace. Malnutrition and underweight of infants are endemic among Tanzanians. About 7.2 percent of infants have severe malnutrition. Only 70 percent of school age going children is able to get registered in primary school. Those who get registered are faced with inadequate facilities at school. Some are forced to sit on the floor during classes. Most Tanzanians are still affected with preventable diseases like malaria, diarrhoea, cholera, anemia, etc, which have been eradicated in other parts of the World. Maternal child and infant mortality rates are still high. In every 1,000 births, 96 infants die compared to only 7 for developed countries. Women in villages spend a lot of time fetching water and firewood. Around 24 percent of all Tanzanians have to walk for more than 30 minutes to reach the nearest water source. In some cases the quality of the water fetched is not guaranteed.

It is evident that many places in the rural areas do not have dependable means of transport, resulting in failure by farmers to send their produce to markets and consumers in urban areas. While some parts of Tanzania would be experiencing food shortage, the same would be in excess supply in another part of the country because of lack of reliable communication. Despite all those problems, the Government resolves to eradicate poverty still remains. Because of that Tanzania joined the International Community in 1995 at the Copenhagen Social Summit in resolving to eradicate poverty globally.

1.2.6 Energy Profile

The energy sector covers non-commercial primary energy sources (mainly wood-fuels) and commercial energy (petroleum, natural gas, hydroelectricity, coal and geothermal energy). Tanzania's energy demand and end-use structure reflects the low level of development.

Wood is the main source of biomass-based fuels. The total forested area of Tanzania is 44 million hectares, mainly savannah and intermediate woodland. About 13 million hectares of these are reserved forests. Village woodlots account for a mere 200,000 hectares. Forest areas are being harvested at a rate faster than the regeneration rate. It is estimated that Tanzania loose about 300,000 to 400,000 ha of forests per year through various causes.

The country has considerable biomass resources in the form of forest and agricultural residues. Possibilities exist for the economic conversion of these resources into electricity and energy for industrial and domestic purposes. However, limited forest and agricultural residues are being used for electricity and mechanical power generation as well as fuel wood substitute in various parts of the country. Currently, they account for at least 10 percent of the nation's energy requirements.

Coal and natural gas are the other commercial fuels with a high potential. Coal reserves are estimated at about 1,200 million tones, of which 304 million tones may be considered proven. A field of 29.02 billion cubic metres of proven, probable and possible recoverable high quality natural gas has been discovered at Songosongo.

Hydroelectric energy is the single most important indigenous source of commercial energy with a potential of 4.7 Gigawatts (GW) of installed capacity and about 3.2GW of firm capacity. Only 15 percent of the potential installed capacity has been developed. Solar, wind and geothermal energy are virtually untapped resources. The mean solar energy density is of the order of 4.5 kW per square metre per day, an indication of its potential for use as an energy source. Low speed windmills also have a potential in the country. Uranium, which is one of the sources of nuclear energy, is known to exist in Tanzania.

Wood-fuels such as fuelwood, charcoal and agricultural residues account for 92 percent of primary consumption while commercial fuels such as electricity and petroleum account for 0.8 percent and 7.2 percent of primary consumption respectively. It is estimated that in Tanzania's final energy consumption was 15.0 million tones of oil equivalent (TOE). The per capita energy consumption is of the order of 0.65 TOE. In 1986, Tanzania consumed almost 1 million tones of petroleum products. The transport sector accounts for nearly 51 percent of the petroleum used while industry accounts for 26 percent, and households for 10 percent of the consumption.

Tanzania is still a relatively small consumer of electricity despite of the existing enormous potential sources. The per capita consumption is 46 kilowatt-hour (kWh). Those who have access to electricity constitute a mere 10 percent of the entire population of which only 1 percent of rural population has access to electricity.

2: NATIONAL INVENTORY OF ANTHROPOGENIC GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1 OVERVIEW OF THE INVENTORY OF GREENHOUSE GASES

An inventory of greenhouse gas emissions and removals in Tanzania was developed in 1993 to 1994 based on United Nations Environment Programme (UNEP)/Organization for Economic Cooperation and Development (OECD)/Intergovernmental Panel on Climate Change (IPCC) guidelines of 1991. The inventory is based on data obtained from 1988 to 1990.

Activity data was based on data survey and statistical information, where available. Where records were not available default data compiled by International Energy Agency (IEA), OECD, Food and Agricultural Organization (FAO) and the IPCC was used. Default emission factors in IPCC guidelines have been applied except for the estimation of methane emissions from municipal waste water treatment. Direct greenhouse gases Carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O) as well as indirect greenhouse gases Nitrogen oxides (NOx) and Carbon monoxide (CO) has been covered.

CO_2 estimates from international bunker fuels have been excluded. Estimates of CO_2 emissions from biomass fuels or biofuels have also been excluded from the inventory. It is assumed that the annual carbon released from biofuels combustion is part of the natural carbon cycle, hence it does not result into net emissions.

The major sectors addressed in the inventory include energy, agriculture, industrial process, waste management, forestry and land use. For each of these sectors an estimation of CO_2, CH_4, N_2O and other gases has been done. The energy sector consists of combustion and non-combustion sub-sectors.

The reliability of the emissions inventory depends on the accuracy of input data and the associated inventory methodology. When input statistics are insufficient or not representative of the real situation the reliability of the output data is affected. At the same time, if emission factors are not suitable for the existing situation the inventory reliability is affected. The availability of activity data has not been easy for many of the sectors except for the commercial energy data, whose records are normally kept by Tanzania Petroleum Development Corporation (TPDC) and the Tanzania Electric Supply Company (TANESCO). Activity data on land-use, land-use changes and forestry is outdated and not continuously recorded necessitating interpolation/extrapolation in order to get the missing figures. Agricultural activity data is crude and is based on the interpretation of cash crop yields, fertilizer imports and annual exports. Activity data on waste management is scattered in different institutions, much of it is neither updated nor regularly collected. Limited surveys have been undertaken to assist in updating the available information and data for calculating emissions.

2.2 OVERVIEW OF EMISSIONS AND REMOVALS OF GREENHOUSE GASES

A summary of the greenhouse gas inventory for 1990 is shown on Table 2.1. This table provides a full account of direct (i.e. CO_2, CH_4 and N_2O) and non-direct emissions (i.e. CO & NO_x) for the sectors of energy, industrial process, agriculture, land-use change and forestry and waste management. In each of these sectors the emissions from the sub-sectors are also estimated and presented. Of total gases emitted (64,885 Gg), CO_2 contributes 91 percent, CH_4 (2.8 percent), CO (6 percent), NOx (0.17 percent), N_2O (0.01 percent). Figure 2.1 shows emissions of greenhouse gases in Tanzania in 1990.

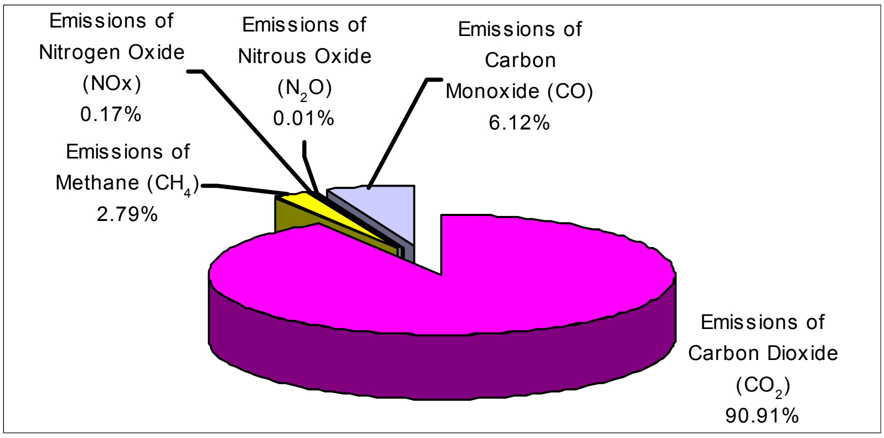

Figure 2.1: GHG Emissions in 1990

Land use and forestry was the major emitter of greenhouse gases (87 percent of all emissions) followed by the energy sector (6 percent) and the agriculture sector 5.7 percent. Least emitting sectors were industrial processes (0.5 percent) and waste management (0.07 percent). Figure 2.2 summarizes the GHG emissions by sector.

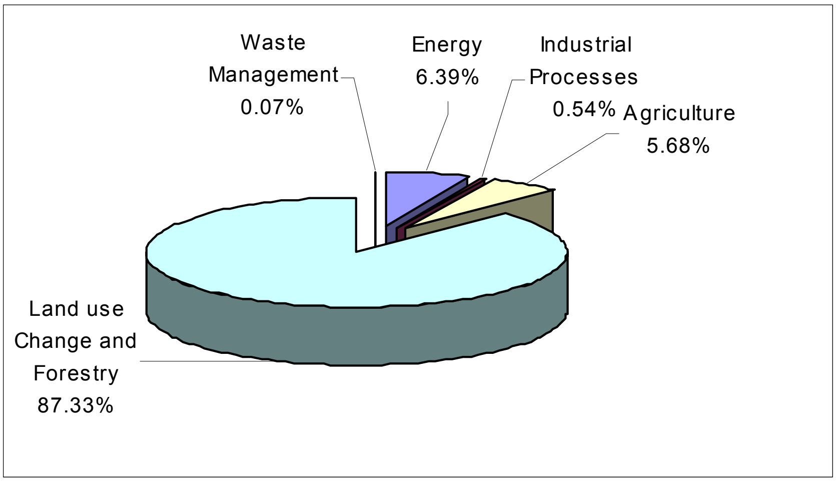

Figure 2.2: 1990 GHG Emissions by Sector

Table 2.1: *Summary of the Inventory of Greenhouse gas Emissions and Removals (Gg) for 1990*

	Gigagrams (Gg)					
	Emissions of Carbon Dioxide (CO_2)	**Carbon Dioxide CO_2 Removals**	**Emissions of Methane (CH_4)**	**Emissions of Nitrogen Oxide (NO_x)**	**Emissions of Nitrous Oxide (N_2O)**	**Emissions of Carbon Monoxide (CO)**
Module 1: Energy						
Fuel combustion						
Stationary Combustion in Industry	559.24	NA	0.207	4.021	0.0005	26.434
Thermal Power Generating Plants	73.79	NA	0.010	0.916	0.0019	0.634
Mobile Combustion Activities	1,124.02	NA	0.291	8.719	0.0248	51.805
Others (fossil fuels in households)	264.74	NA	0.018	0.189	NA	0.003
Traditional biomass energy	NA	NA	424.481	54.110	1.9086	1,550.000
Coal activities	NA	NA	0.821	NA	NA	NA
Natural Occurring Exploited Gases	1.26	NA	NA	NA	NA	NA
Subtotal module 1	2,023.05	0.00	425.83	67.96	1.94	1,628.88
Module 2: Industrial Processes						
Non-Metal Processes (Cement)	343.634	NE	NA	**NA**	**NA**	**NA**
Non-Mineral Processes (Pulp and Paper)	5.787	NE	NA	**NA**	**NA**	**NA**
Subtotal module 2	349.421	NE	NA	**NA**	**NA**	**NA**
Module 4: Agriculture						
Rice Cultivation	**NA**	NA	84.756	**NA**	**NA**	**NA**
Enteric Fermentation	**NA**	NA	872.275	**NA**	**NA**	**NA**
Manure Management	**NA**	NA	8.057	**NA**	**NA**	**NA**
Nitrogenous Fertilizers	**NA**	NA	NA	NA	0.5673	NA
Burning of Agricultural Residues	**NA**	NA	323.002	20.728	0.5730	1,053.477
Burning of Savannas	**NA**	NA	47.825	21.390	0.5920	1,255.396
Subtotal module 4	NA	NA	1,335.915	42.118	1.7323	2,308.873
Module 5: Land-use Change & Forestry						
Forest clearing for agricultural lands	727.060	NA	2.483	0.617	0.0170	27.158
Abandonment of Managed Lands	NA	1,930.500	NA	NA	NA	NA
Forests subject to human activities	55,937.510	1,814.770	NA	NA	NA	NA
Others (shifting cultivation and dams)	NA	NA	0.579	0.139	0.0050	4.173
Subtotal module 5	56,664.570	3,745.270	3.062	0.756	0.0220	31.331
Module 6: Waste Management						
Municipal Solid waste disposal	NA	NA	8.363	NA	NA	NA
Waste Water Treatment	NA	NA	2.308	NA	NA	NA
Others (Industrial waste Management)	NA	NA	33.108	**NA**	NA	NA
Subtotal module 6	NA	NA	43.779	**NA**	**NA**	**NA**
Total	**59,037.04**	**3,745.270**	**1,764.81**	**110.83**	**3.69**	**3,969.08**
Global Warming Potential (GWP)						
100 years integration	1.0	1.0	21		310	
Gg CO_2-equivalent	59,037.04	3,745.27	37,060.91		1,143.93	

Notes: (1) CO_2 estimates were obtained by the "top-down" approach. The technology-based approach gives slightly higher estimates by up-to 10 percent.
(2) Some figures are slightly higher or lower by up to 0.25 Gg due to rounding-off at various stages during the calculations.

2.2.1 Global Warming Potential (GWP)

Global Warming Potential (GWP) for direct greenhouse gas emissions in 1990 with a 100 year time horizon, has been calculated in accordance with the IPCC guidelines. As per the IPCC guidelines nitrous oxide has the highest GWP of 310 followed by methane with 21. Using the GWP CO_2 emissions have the largest share of (61 percent) of the inventory followed by methane (38 percent) and nitrous oxide (1 percent). Figures 2.3 and 2.4 show the greenhouse gas emissions by gas and by sector, respectively, using the GWP index.

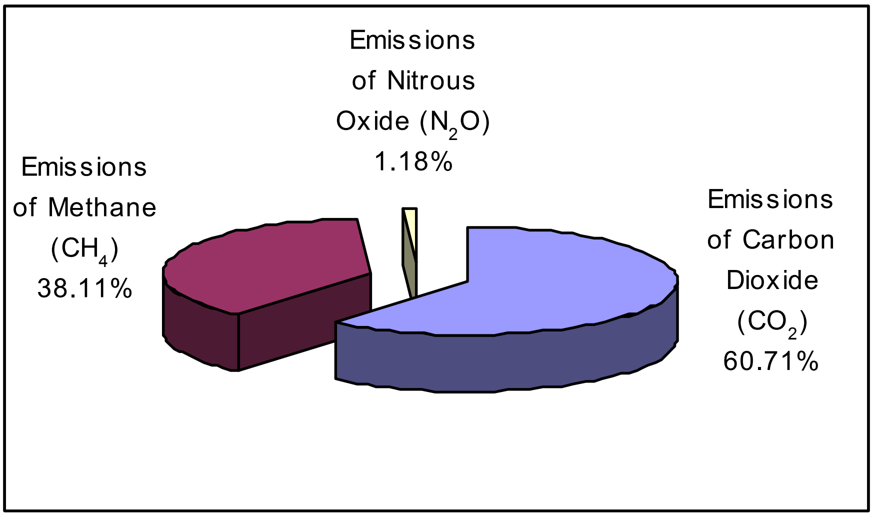

Figure 2.3: *GWP of Direct GHGs with a 100-Year Time Horizon for the Year 1990*

The inventory also indicate that in 1990 land use and forestry was the major emitter of GHGs contributing 58 percent of all the emissions, followed by agriculture (29 percent), and energy (12 percent) (Figure 2.4). Waste management and industrial processes contributed small amounts of 0.9 percent and 0.4 percent respectively.

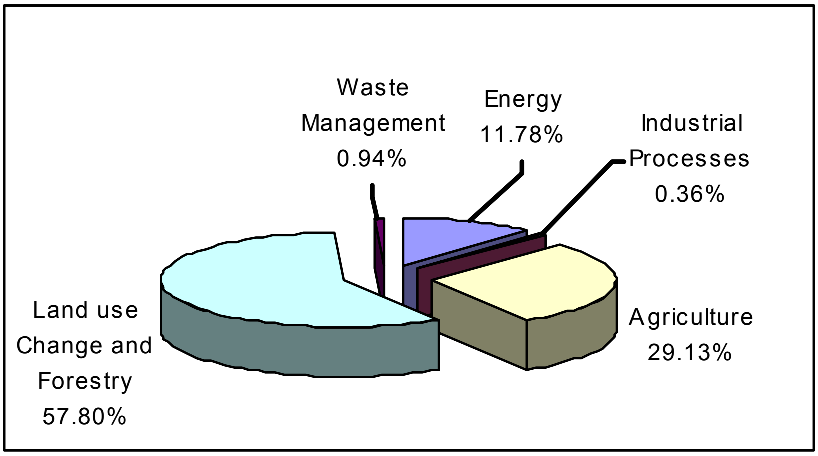

Figure 2.4: *1990 GHG Emissions by Sector using GWP Index*

2.3 GAS-SPECIFIC EMISSIONS AND REMOVAL OF GREENHOUSE GASES

2.3.1 Carbon Dioxide (CO_2)

Taking CO_2 as the main emission, land use and forestry is the major source emitting 96 percent followed by energy 3 percent and industrial processes, which contributed 0.6 percent of the total emissions. Removal of CO_2 is 6 percent of total CO_2 emitted by various sources.

Figure 2.5 shows carbon dioxide emissions from various sectors of the economy.

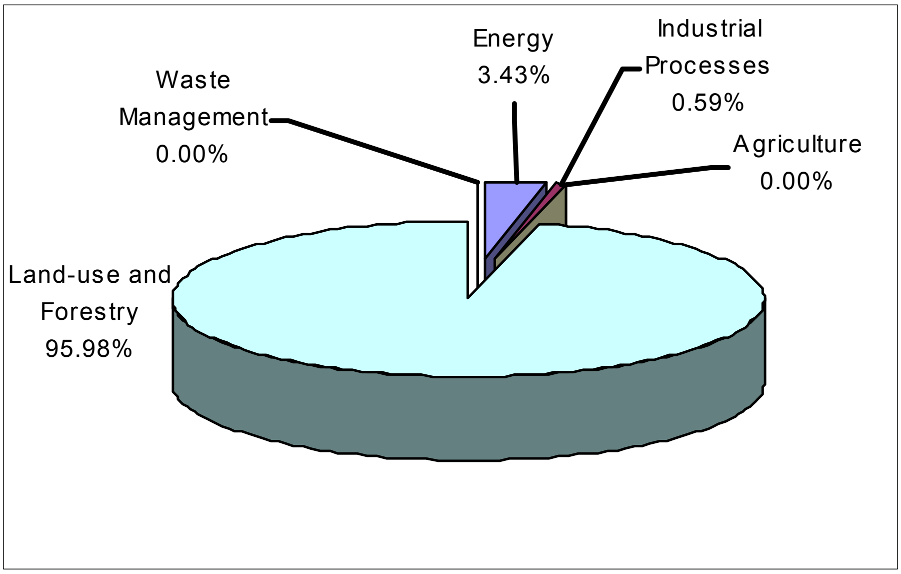

Figure 2.5: *Carbon Dioxide emissions by sector*

(i) *The energy sector*

The energy sector, the primary fossil fuel combustion sector, consists of industry, transport, household and commercial and energy transformation sub-sectors. The energy transformation sub-sector consists of thermal power generation plants by the power utility company and few commercial and residential users as well as petroleum refining.

In 1990 CO_2 emissions from fossil fuel combustion accounted for 2023 Gg. CO_2 emission from fossil fuel combustion from mobile sources including the transport transportation sub-sector and farm and construction equipment was the largest source accounting for 56 percent of total CO_2 emissions. Stationary combustion in industry, refinery and other fuel transformation accounted for 28 percent followed by 13 percent in the household and commercial sub-sector, and 4 percent in the thermal power generation (energy transformation). Figure 2.6 summarizes emissions of CO_2 in the energy sector.

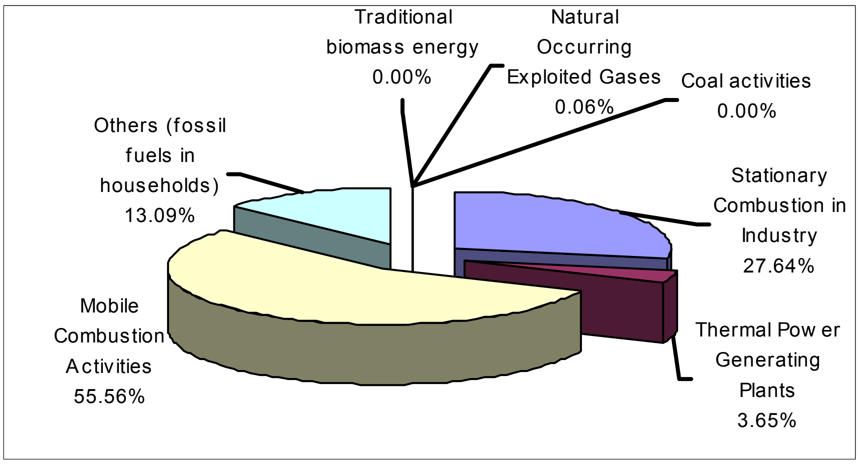

Figure 2.6: *Carbon dioxide Emissions in the Energy Sector 1990*

(ii) *Land use and forestry*

(a) CO_2 Emissions

The land use and forestry sector is the major emitter of CO_2 according to the national inventory report of 1990. It is also the only sink for the removal of CO_2 in the country. In 1990 this sector contributed 56,664 Gg of CO_2 to the atmosphere and removed 3,745.3 Gg of CO_2 from the same; the net emission was therefore 52,919 Gg. This sector comprised of forest and grassland clearing for agriculture, abandonment of managed lands, assumed to regrow naturally for 20 years and above, changes in forest and other woody biomass stocks and others (shifting cultivation and man-made flooded lands). Forests subject to human activities were the largest sources of emissions accounting for 93 percent of the total emissions, followed by forest and grassland clearing for agriculture, which contributed 1.2 percent. Figure 2.7 shows emissions and removals of GHGs in the forestry and land use sector.

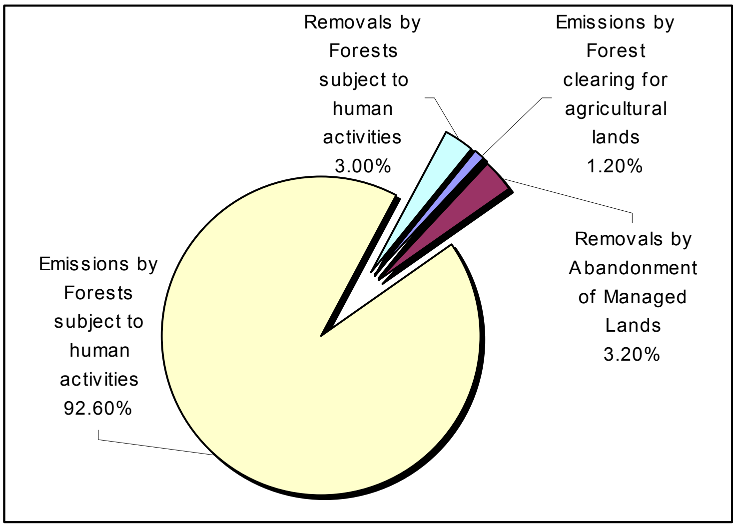

Figure 2.7: *Land use and Forestry CO_2 Emissions and Removals*

(b) *CO_2 Removal*

The land use and forestry sector is the major sink for CO_2. In 1990 total CO_2 removal by change in forest and other woody biomass stock and the abandonment of management lands was 3,745.3 Gg. Forests subject to human activities (management of forests) accounted for half of the removals while another half was contributed by abandonment of managed lands.

- Management of forests comprises plantation forests, village woodlot, natural forests subject to human activity, wood exploited informally for woodfuel, and urban and rural tree planting.
- Abandonment of managed lands comprises the abandoned wooded grassland and tropical open forests.

Figure 2.8 summarises the CO_2 removals by sinks in the forestry and land use sector in 1990.

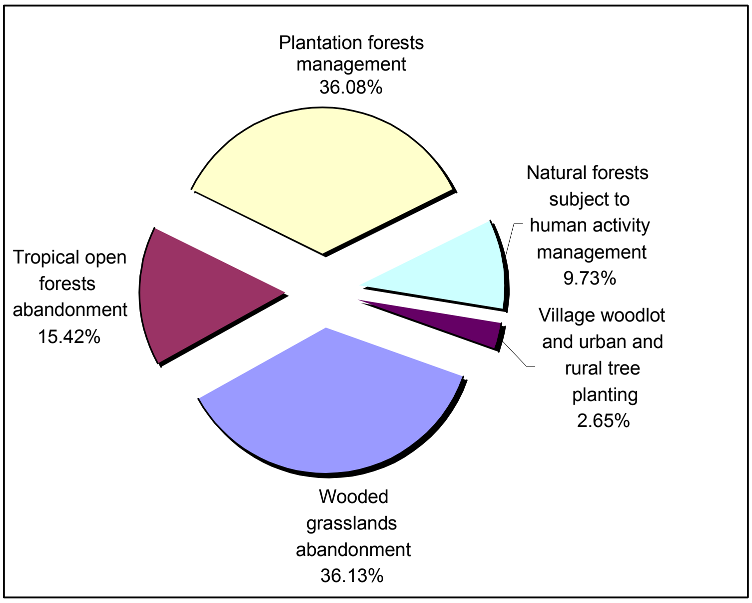

Figure 2.8: *Carbon dioxide Removals by Sinks in Tanzania 1990*

Plantation forests and abandonment of wooded grasslands were the largest sinks with a share of 36 percent each, followed by the abandonment of tropical open forests (15 percent). Other sinks resulted from management of natural forests subjected to human activity, (9.73 percent) and lastly, the village wood-lot and urban and rural tree planting (2.65 percent).

(iii) *Non-energy industrial processes*

In 1990, CO_2 emissions from industrial processes mainly cement and pulp and paper production contributed 349 Gg (i.e., 0.6 percent) to the total emissions. Cement production accounted for 98 percent while 1.7 percent was from pulp and paper production. Emission from this sector is insignificant when compared to other emission sources of energy and land use change and forestry.

2.3.2 Methane (CH_4)

Methane emission in various sectors of the economy for 1990 is summarised in Figure 2.9.

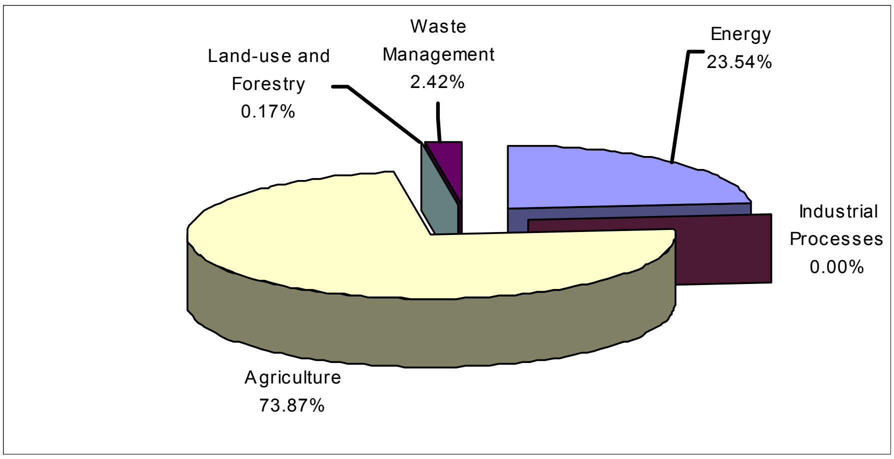

Figure 2.9: *Methane Emissions by Sector*

From the 1990 inventory, the sources of CH_4 emission are energy, agriculture, land use change and forestry and waste management. The estimation of the emission has been done for each sub-sector. Emission factors used in the estimation of emission from waste water management have been developed in the country by local researchers, because the IPCC emission factors were not suitable for the local situation. The total methane emissions were of the order 1,765 Gg. Agriculture was the largest source contributing to 73.9 percent. Other sectors were energy (23.5 percent) followed by waste management (2.4 percent) and land use change and forestry (0.2 percent) [refer to Table 2.1].

(i) *Agriculture*

Methane emissions from agricultural activities in Tanzania are attributed to rice cultivation, enteric fermentation in ruminant animals, animal wastes or manure management, burning of savannas and burning of agricultural residues. Figure 2.10 shows the contribution of each activity.

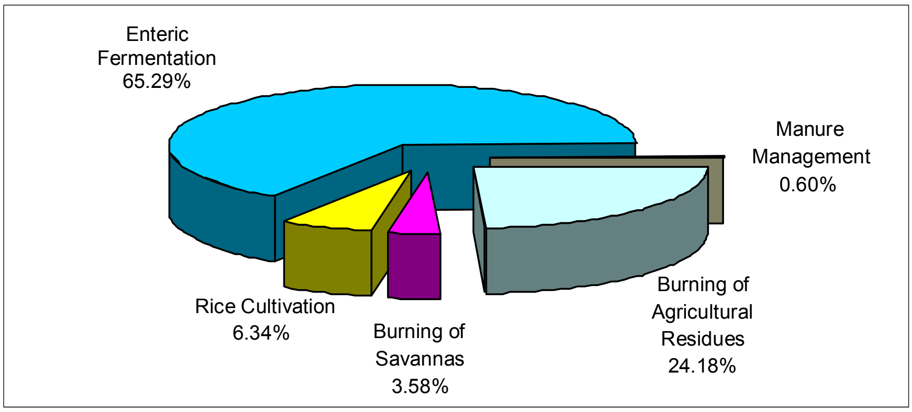

Figure 2.10: *Methane Emissions in the Agriculture sector*

(ii) *Energy*

In the 1990 inventory, Methane emissions in the energy sector shows that the major emitter is traditional biofuels. Other activities including thermal, mobile and stationary combustions as well as coal and natural occurring explored gases are insignificant.

(iii) *Other Sources*

Solid Waste and Waste Waters

In 1990 direct emissions from solid wastes arising from industrial processes accounted for 75.6 percent of all CH_4 emissions. Other sources were Municipal solid waste disposal on land and wastewater treatment, as shown in Figure 2.11.

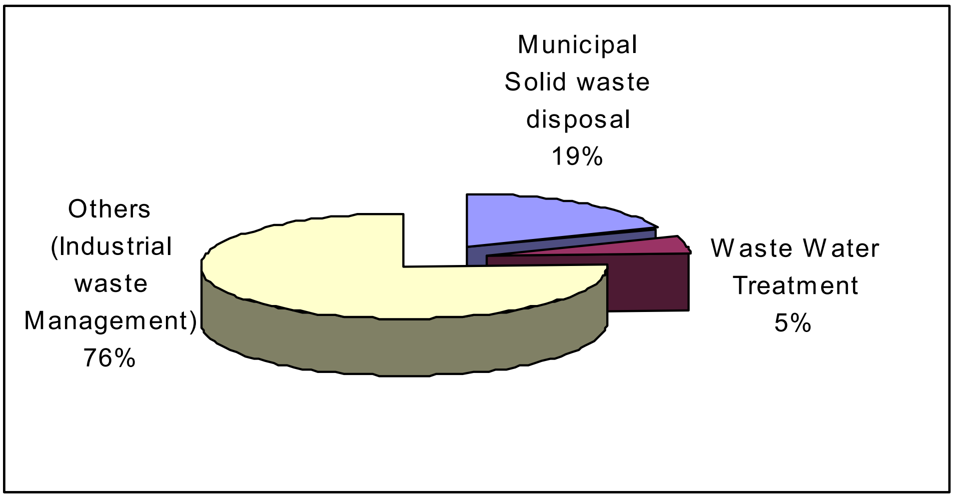

Figure 2.11: *Methane Emissions from Waste Management*

Methane emissions from land-use change and forestry

Activities contributing to methane emissions in the forestry and land-use sector are abandonment of managed lands and the agriculturally impacted soils. In the 1990 inventory, the emitting sub-sectors were forest and grassland conversion and flooding lands. Total emissions from this sector were as shown in Table 2.1 and Figure 2.12.

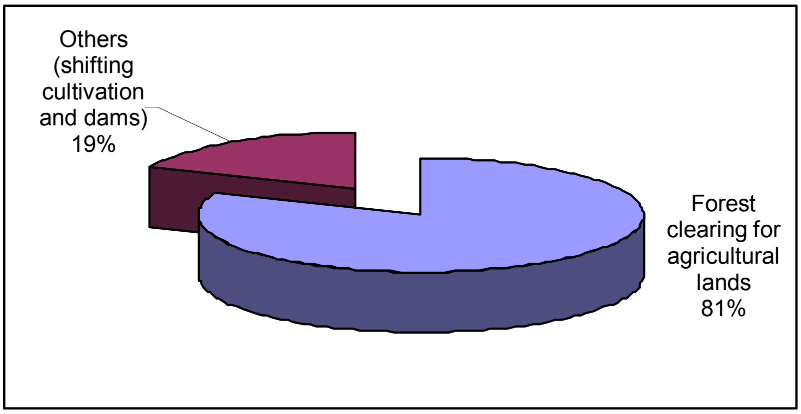

Figure 2.12: *Methane Emissions from Agriculture*

2.3.4 Nitrous Oxide

In 1990 GHG inventory agriculture and energy were the major emitters of N_2O. The total emission was 3.69 Gg. Of the total emissions, fuel combustion contributed 52.6 percent, agriculture 46.9 percent and land-use change and forestry 0.5 percent. However, when compared to other emissions the N_2O emissions are insignificant.

2.3.5 Non-Direct Emissions

The 1990 inventory has detailed emissions of NO_x, CO and NMVOC. For NO_x the emitting sectors were energy (61.5 percent), agriculture 37.8 percent and 0.7 percent from land use change and forestry. The total NO_x emissions in 1990 were 111.45 Gg. For CO, the same sectors were contributors of the total emission of 3,969.28 Gg. Burning of agricultural residues and savanna burning contributed 58.2 percent, followed by fuel combustion (41 percent) and lastly the land use change and forestry (0.8 percent). The identified major source of NMVOC was fuel combustion in the transport sub-sector, which contributed 7.36 Gg. When the emissions of NO_x, CO and NMVOC are compared, CO is a significant source followed by NMVOC and NO_x.

2.4 CONCLUDING REMARKS

The study on the development of an inventory of sources and sinks of greenhouse gases in Tanzania cannot be considered to have come to an end. On the contrary it has provided a basis for future work including that of regular reviews and updates of the same. The study has also identified a number of areas on which further work needs to be done, including working on country specific emission factors.

The results of the study shows that the major sources of greenhouse gases in Tanzania are land use change, agriculture and the energy sectors, while the forestry sector provides a major sink. Using the Global Warming Potential, the major greenhouse gas is carbon dioxide, which contributes about 59% of all emissions followed by methane contributing about 40%. Carbon dioxide is the most important gas in the forestry and land use as well as energy sectors while methane is more significant in the agriculture and waste management sectors.

Tanzania is an insignificant emitter compared to other countries; emissions will grow especially in the energy sector. However, there is a need to use less polluting technologies and the development and use of clean technology and efficiency improvement has to be addressed.

It should be noted that there has been a significant discrepancy between the 1990 and 1994 GHG inventories. The calculations results for the 1994 inventory indicate a significant increase in both non-CO_2 greenhouse gase emissions and CO_2 emissions compared to the estimates reported in the previous study. This may be due to the refinement of both the revised IPCC methodology and activity data. In this regard therefore, Tanzania decided to report the 1990 baseline while putting the 1994 GHG inventory report as an annex (See Appendix 2) to this National Communication, this Appendix will form the basis for the second national communication.

3: GREENHOUSE GAS MITIGATION

3.1 OBJECTIVES OF THE MITIGATION ANALYSIS

A study on technological and other options for the mitigation of greenhouse gas emissions in Tanzania has been undertaken. The study was carried out with the support of GTZ and was updated with GEF/UNEP support. The mitigation analysis had the following objectives:

a) Identification of technologies that are associated with GHG emissions in various sectors;
b) Identification of the technical possibilities of minimising GHG emissions;
c) Identification of the appropriate environmentally benign technologies available for Tanzania, including its specific reduction potential and associated costs;
d) Investigation of various options for GHG abatement including retrofitting, and emissions reductions on equipment;
e) Exploration of the link between energy efficiency, mitigation of GHG emissions and associated costs;
f) Proposal of technological strategies and policy options to mitigate the emissions of GHG based on an abatement cost curve;
g) Recommendation of possible targets for GHG mitigation or stabilisation particularly in the national energy policy; and
h) Building an indigenous capacity in the assessment of climate issues.

Various sectors have been analysed and technological and non-technological options for the mitigation of GHGs in the respective sectors identified. The sectors included:

i) The energy sector, covering energy forecasts and energy supply analysis;
ii) The industrial sector covering demand side analysis and energy efficiency;
iii) Cement and pulp plants as well as waste disposal management;
iv) The transportation sector covering the demand side analysis and energy efficiency;
v) The agricultural sector covering efficiency in agricultural practices and livestock keeping;
vi) The forestry sector covering land use and forestry, a forestation and reforestation;
vii) The household and commercial sector covering demand side analysis; and
viii) Macroeconomic analysis, energy pricing and marginal cost analysis and evaluating the abatement scenarios.

An analysis of the economic and other implications of the identified mitigation analysis has been carried out, forming the basis for screening the mitigation options. Multi-criteria assessment of the significance and impacts of the mitigation options has also been undertaken.

3.2 THE IDENTIFICATION OF GREENHOUSE GAS MITIGATION OPTIONS

The study has explored the various mitigation technologies, their characteristics and costs. Sectors analysed have included energy; industrial; transport; forestry and land-use; agriculture and livestock; household; commercial; and informal energy use. A sectoral analysis has been done and a number of technological and non-technological options have been identified and will serve as input into the national plans. Table 3.1 shows some of the mitigation options analysed in the study.

Table 3.1: *Some GHG Mitigation Options*

Sector	Option	Description
Energy Supply	(i) Technological • Advanced electricity generation technologies • Efficiency improvements • Charcoal production • Coal mining • Renewable technologies (ii) Non-Technological • Energy pricing policy • Regulations and standards • Bonus and penalty	• Install 230 MW of combined-cycle power plants instead of simple cycle gas turbines • Interconnecting to neighbouring countries by the year 2000 • Installation of gas power by the year 2000 • Increase the efficiency of existing power generation systems by repowering and improving transmission and distribution systems • Improve the conversion efficiency of charcoal kilns • Optimize methane release from coal mines • Use solar collectors, photovoltaics, wind turbines, and biomass energy sources • Energy pricing policy which stimulate the efficient development and utilization • Regulations and standards to safeguard the environment and property against the misuse of energy and accidents • Bonus and penalty schemes in the form of direct rewards, or indirectly in the form of tax rebates, tax holidays, or loan interests
Industry	*Cement Production* • Production management • CO_2 recovery system • Fuel switching • Production mix *Pulp and Paper* • Efficiency improvements • Recovery of CO_2 *Other Industries* • Energy efficiency improvements	• Install automatic control systems for reducing the amount of fuel used and improving production efficiency • Install CO_2 recovery systems. Recovered CO_2 can be used for other industrial applications • Substitute natural gas for fuel oil in two production plants • Produce blended cements such as pozzolanic cements, blast furnace slag cement, and Portland cements in order to reduce the amount of fuel used for calcination and the amount of lime used per unit of cement produced • Optimize the recovery boiler in order to reduce both the amount of lime and energy used • Recover CO_2 from calcination by the absorption of CO_2 • Improve efficiency in existing plants through maintenance, improved steam production and management, improvements to motor drive systems, cogeneration, and power factor correction
Transportation	• Vehicle efficiency • Improve system efficiency • Modal split • Urban transport • Fuel substitution	• Improve the technical efficiency of vehicles • Improve traffic flows, increase vehicle load factors, improve vehicle maintenance, traffic operations, training and management • Rehabilitate and expand the rail system • Implement city trains in Dar es Salaam • Use of Compressed Natural Gas (CNG) Vehicles*
The Household and Service Sector	• Electrical appliances • Cookstoves • Waste management • Fuel switching	• Improve the efficiency of electrical appliances • Increase the efficiency of biomass cookstoves • Waste management including landfills and waste water treatment • Population to switch from woodfuel to charcoal or kerosene, or liquefied petroleum gas (LPG) and electricity • Switch from conventional rural electrification using diesel generator sets or grid power extension to centralised solar electrification
Agriculture and Livestock	• Agricultural practices • Livestock husbandry	• Reduce methane and carbon emissions through better practices related to fertilizer application, rice cultivation, and the loss of organic carbon from cultivated soils • Better husbandry, including better breeding and feeding practices
Land-Use and Forestry Sector	• Forest management • Grasslands and rangelands	• Maintaining existing stocks through forest protection and conservation; and expanding carbon sinks by means of afforestation, reforestation, and enhanced natural regeneration and agroforestry practices • Maintaining or increasing carbon sequestration through better soil management and sustainable agricultural practices

* Once the natural gas project is on stream in Dar es Salaam, captive vehicle fleets (that is the commuter buses, taxis, delivery trucks and any other vehicles with relatively high mileage but restricted range) will be converted to use CNG as an alternative fuel. It is assumed that by the year 2010 the available natural gas will have been exploited substantially, and CNG vehicle technology will be available in the country by then. Penetration of the CNG vehicles by the years 2010 and 2020 is estimated at 3 percent and 6 percent, respectively.

3.3 MACRO ECONOMIC ANALYSIS

The development of the long-term macroeconomic scenario was undertaken using a Cross Impact Matrix analysis. In the analysis two major uncertainties for the long-term development scenarios were identified. The first uncertainty is manifested in the external factors, which include the evolution of export commodity prices, the foreign debt service and external development support. The second uncertainty is manifested in the internal factors, which include structural adjustment policies, provincial development strategies, land allocation policies, agricultural development priorities and the exploitation of abundant natural resources.

The most likely scenario for the long-term development of Tanzania can be characterized by the predominance of structural reforms in the short-term, followed by a more balanced growth strategy in the long-term. Therefore a combination of the above scenarios results into a composite scenario. The economic development scenarios developed are consistent with the targets of the Tanzania's Vision 2025.

3.4 RANKING OF THE MITIGATION OPTIONS

A multiple criteria assessment method was used to rank the mitigation options. This was done with the help of Expert Choice software. Due to the relatively high number of options, they were evaluated against standards rather than against each other. Figure 3.1 shows the results of the ranking process.

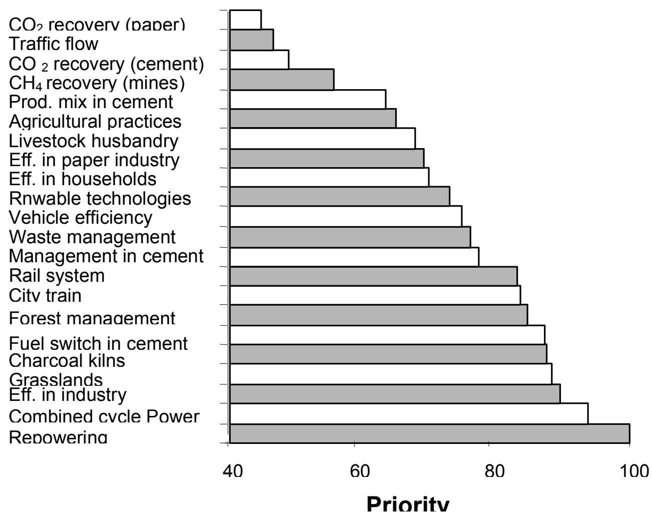

Figure 3.1: Overall Ranking of Mitigation Options

Identified mitigation options include, among others, the applications of efficiency technologies in energy production and use, efficient technologies for cement, pulp, and paper production, efficiency in rice cultivation, and better animal feed practices. Others are fuel switch in the transport sector, transport management and optimisation in transport modes, afforestation, forest management, and urban tree planting. A specific sectoral analysis and ranking has also been done for all the relevant sectors.

3.5 MITIGATION ANALYSIS FOR THE ENERGY SECTOR

The greenhouse gas mitigation analysis in the energy sector in Tanzania suggests a number of ways in which the sustainable energy development can be achieved through various interventions. These include:

- Energy supply options, including development of renewable sources of energy and use of clean technologies in thermal electricity production; and
- End use options, including use of efficient devices in households, commercial, and industrial sectors.

3.5.1 Renewable Energy Development

The most important renewable energy options identified are hydropower generation, mini-hydropower, biogas, and solar energy. Intervention in large-scale power stations development includes advancing investments in planned hydropower plants so as to phase out the old thermal plants. Although investment costs will be higher than thermal options, hydropower generation has lower operation and maintenance costs and a high CO_2 abatement potential.

3.5.2 Cleaner Thermal Technologies for Electricity Generation

Clean thermal technology for electricity generation targets at converting simple cycle thermal power plants located in Dar es Salaam, which are interconnected to the grid to combined cycle which will ultimately run on Songo Songo natural gas and switch from using industrial diesel oil (IDO).

Combined cycle plants have relatively high fuel combustion efficiencies of about of 57% as compared to 35 - 40% for the simple cycle. In addition, combined cycle plants have short lead-time and very low emission levels of NO_x The exhaust gases consist of typically 3.0 to 3.5 ppm CO_2 (by volume), corresponding to 0.4 kg CO_2/ kWh.

3.5.3 End Use Energy Intensity Reduction

Energy intensity reduction has been studied in the tobacco and cigarette, food and beverage, iron and foundry, aluminium, rubber and plastics, cement, glass, chemical, pulp and paper, textiles, leather, petroleum refinery, brick making, fish smoking and sugar sub-sectors. Substantial energy saving can be achieved through good housekeeping practices. Other measures include the installation of heat recovery systems, and automatic control systems, fuel switching, proper orientation of buildings at the designing stage, optimum use of natural ventilation and sunlight, and setting energy efficient standards for motors, lighting systems, air-conditioning, photocopiers, refrigerators and freezers. The following are specific areas of high priority (Table 3.2):

Table 3.2: *Mitigation options for Energy intensity reduction in industries*

Mitigation optios	Description
Efficient furnaces	• Thermal efficiency of furnaces improvement to between 55 and 60 percent
Boiler efficiency	• Installation of modern boilers to achieve efficiencies of between 90 percent and 95 percent.
Power factor correction	• Power factor correction to an acceptable level of 0.9 will lead to significant GHG emissions reduction of up to 43 percent.
Efficient motors:	• Replacing 'Totally Enclosed Fan Cooled' (TEFC) motors with efficient motors implies power savings of up to 15 percent
Fuel switching:	• Switch from coal and heavy fuel oil, industrial diesel oil to natural gas. Energy intensity and GHG emissions will be reduced

Table 3.3: *Projected Market Penetration of Energy Technologies*

Reduction option/ Technology	Technology/ Capacity	Type of fuel To be replaced	Penetrating in 2010	Penetrating in 2030
Efficient lighting	Bulbs	el-diesel	1,000,000	4,000,000
Power factor correction	1MVAR	el-diesel	100	200
Efficient motors	1,000 Kw	el-diesel	11000	20000
Combine Cycle Power Plants	50 MW	diesel	5	10
Biogas from landfills	1 Landfill (1MW)	el-coal	1	1
Hydro power	100 MW	diesel	10	20
Biogas for rural households	1 digesters	wood	4000	10000
Efficient boilers	10 tonnes	coal	80	100
Efficient furnaces	2 MW	coal	10	30
Mini-Hydro	550 kW	coal	40	80
Solar PV electricity	60W	diesel	600	1200

el-diesel = electricity from diesel plant
el-coal = electricity from coal plant

GHG emissions reduction options for the energy sector in Tanzania, identified in Table 3.3 are ranked using a cost curve in Figure 3.2.

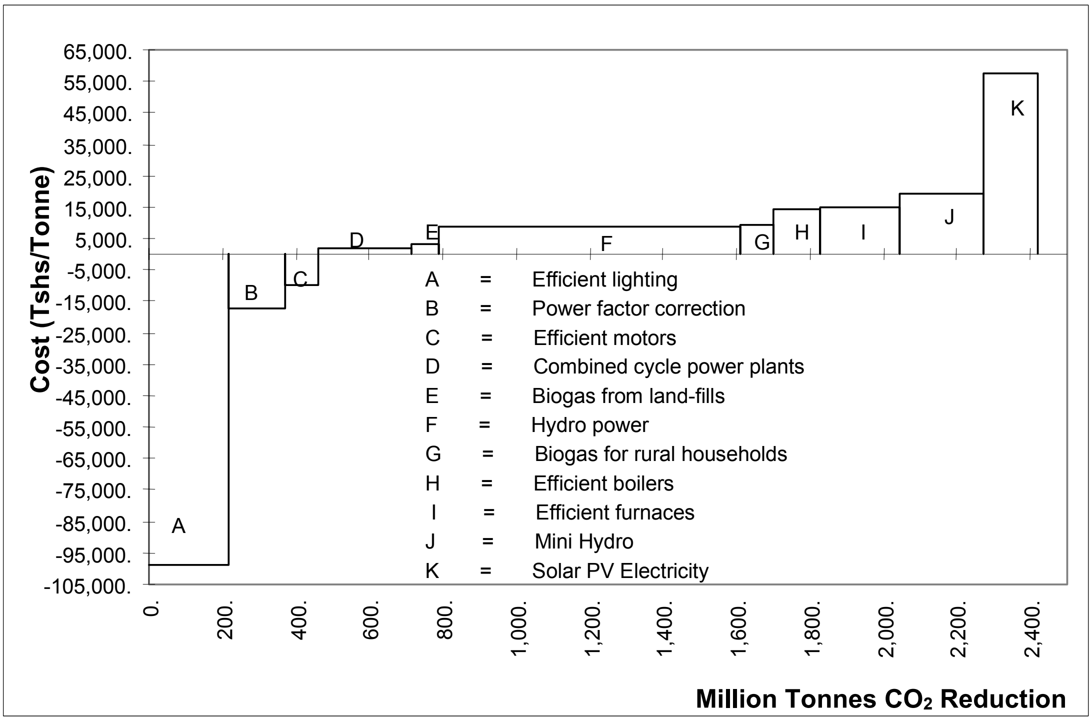

Figure 3.2*:* *CO_2 Mitigation Cost Curve for Energy Sector Options for year 2030*
Note: 1US$=Tshs 800 (in 1999)

3.6 NON-ENERGY GHG MITIGATION OPTIONS IN INDUSTRIAL SECTOR

There is a number of non-energy technological options associated with the two major industrial processes, namely cement and pulp and paper production, studied during preparation of the 1990 GHG sinks and sources inventory. These options were evaluated during the preparation of technological options for GHG mitigation, and they are discussed as summarized in Table 3.4:

Table 3.4: *Non-Energy Mitigation Options in Industrial Sector*

	Option	Description
	Cement Production	
1	Installation of a CO_2 recovery system, CO_2 can be used for other industrial applications	Reduces the amount of CO_2 emitted to a large extent. It is expensive because of high dust load in flue gases
2.	Production of blended cements such as pozzolanic cements, blast furnace slag Portland cements	Reduces the amount of fuel used for calcination and the amount of lime per a given quantity of cement production rate
3	Recovery of waste heat	Reduces the necessary length for pyroprocessing, shorter kilns are needed
	Pulp and Paper Production	
1.	Optimization of the recovery boiler	Reduces the amount of lime needed, uses less energy and not costly
2.	Recovery of CO_2 from calcination by absorption of CO_2	Reduces most of the CO_2 and uses existing installations

3.7 NON-ENERGY GHG MITIGATION OPTIONS IN TRANSPORT SECTOR

Significant opportunities now exist for Tanzania to adopt more efficient transport paths, which can yield gains in terms of energy consumption and some environmental benefits. Among the most efficient paths, the summary of options in Table 3.5 has been recommended: ([4])

Table 3.5: *Non-Energy GHG Mitigation Options in Transport Sector*

Mitigation option	Description
a) Improved mass Transport systems	• Improved management and planning based on careful transport studies • Appropriate pricing structures, • More rational routing and use of buses (50 to 100 seats buses at peak hours, and 20 to 50 seats during off-peak hours) • Introduction of urban light rail systems and public sub-urban rail systems
b) Improved freight Transport:	• Use of long road haulers on selected routes, • Improved railway systems, • Enhanced sea transport. • Use of wider and multiple lines, • Route rescheduling and reduced rolling load
c) Improving vehicle efficiency:	• Formulating standards and regulations for vehicle imports • Provision of well-managed vehicle maintenance • Increase the local production of spare parts, • Proper tuning-up of car engines • Creating facilities capable of producing spare parts that fit the different makes of vehicles (that is unipart factories) should be encouraged;
d) Improving transport system efficiency:	• Overall traffic management needs improvement • Restricted zones in the city and municipalities • The use of speed limits • Parking meters, parking lots area licensing, • Co-ordinated signalling, • Road and traffic signs, • Controlling street trading, • Allocating special lanes for buses;
e) Promotion of non motorised transport:	• Pipeline transport for oil and gas transportation. • Establishing restricted lanes for push/pull carts, bicycles • Special walkways and foot bridges
f) Improved road and telecommunications infrastructure:	• Construct ring roads around cities and municipalities. • Develope a telecommunications infrastructure to save on trips • Proper use of cheaper modern systems such as telefaxes, and the internet will reduce the need to travel
g) Land Use planning:	• Create special zones with all the essential social services (schools, hospitals, pharmacies, offices, and commercial and leisure centres) around surbabs.

3.8 MITIGATION OPTIONS FOR THE FORESTRY AND LAND-USE SECTOR

The greenhouse gas mitigation analysis in the forestry sector in Tanzania suggests a number of ways in which the sustainable management of forest resources can be achieved. These can be grouped into two categories namely:

- Interventions that would create public good; as such, forest protection and conservation fall under this category. There are many conservation activities which create private good (steep slope farming and tree cutting restrictions in private farms), or a combination of both public and private good].
- The other category involves the establishment and management of forest plantations including the sustainable harvesting of the forestry products, be it timber or inputs for bioenergy production. Such projects are even attractive for private investment.

3.8.1 Identification of the Mitigation Options

Potential forestry projects that would lead to greenhouse mitigation form the basis of the forestry mitigation assessment have been identified. These include:

- ♦ Commercial/industrial forest plantation (Sao Hill Forest Phase II);
- ♦ Extension and replanting of other industrial forest plantations;
- ♦ Small holder or village tree growing for multiple purposes;
- ♦ Natural/catchment forest protection; and
- ♦ Bioenergy from forest waste

Commercial Forest (Sao Hill Forest) Plantation

The Sao Hill forest plantation is located in Mafinga, Iringa, in the southern plateau of Tanzania. The forest plantation has been developed for timber and pulp production. The Sao Hill plans and projections contained in the Tanzania Forestry Action Plan (TFAP) aim at expanding the forest from its current 40,000 [estimate for 1986] to 60,000 hectares. It is assumed that half of the area will be planted with Pine and Cypress for sawlogs, while the other half will be planted with Pine for pulpwood. The rotation for the two species is 25 years and 15 years, respectively. The Sao Hill Forest plantation and the expected expansions are as shown in Table 3.6, which will form a mitigation option if implemented properly. The Mean Annual Increment for the two species in m^3 of biomass/ha/annum is 25 and 17 for sawlogs and pulpwood respectively

Extension and Replanting of Other Industrial Forest Plantations

Industrial plantations that can be expanded and their respective acreage, are as shown in Table 3.6.

Table 3.6: *Possible extension of other forests*

	Name of the Forest	Main Species	Existing Forest Area (Hectares)	Possible Extension of Planted Area (Hectares)
1.	Meru	Eucalyptus	3,482.3	821
2.	Training Forest	Eucalyptus	660*	25
3.	Usa	Loliondo, Grevillea	944.9	50
4.	West Kilimanjaro	Grevillea	3,966.9	646
5.	North Kilimanjaro	Pine (Sawlog)	3,809.2	1,000
6.	Shume	Eucalyptus	1,515	131
7.	Magamba	Black Wattle	849	243
8.	Longuza	Teak	1,608.1	2,850
9.	Kwamkoro	Maesopsis, Mtambara	647.4	400
10.	Ukaguru	Teak	965.5	68
11.	Mtibwa	Teak	999.5	768
12.	Ruvu	Cassia	617	2,662
13.	Rondo	Mvule, Teak	1915	6,000
14.	Matogoro		864.5	11,281
15.	Kawetire	Eucalyptus	871.9	25,000
16.	Kiwira	Eucalyptus	1,243.3	300
17.	Rubare		94.6	11
18.	Rubya		1098.2	3300
19.	Ruhindi		3209.3	7800
	Total		28701.6	62592

Source: (2)
* Area in 1986

Small Holder or Village Tree Growing for Multiple Purposes

Smallholder or village tree growing and management for multiple purposes includes agro-forestry, with wood fuel provision for own-use. The priority given by local people to growing trees for woodfuel varies greatly according to the farming systems and the amount of accessible forest or other tree resources in relation to consumption levels. Tree growing can also be for the sale of poles and fuel as a cash crop to local rural and urban markets. Useful quantities of wood for own-use usually arise from such operations as urban and community forestry and enhanced regeneration.

Natural/Catchment Forest Protection

Natural/catchment forests protection is another mitigation option identified in Tanzania, which will maintain the existing stands of trees/sinks and the proportion of forest products currently in use. This may involve the following activities:

- The sustainable use of forest resources through the harvesting of branches for food for animals, as well as fallen wood for woodfuel together with some tree cutting in natural forests on village or state lands, at or below the rate of natural regeneration;
- Improved management for the greater productivity of village forest land. Also improved control against unlicensed felling in these forestlands is important in order to raise village incomes but does not, of course, *add to the total supplies*. Improved control can also reduce the destructive impacts of indiscriminate felling, such as soil erosion, loss of valuable species, etc.
- Improved management of and tighter controls of state forests. In the short term, the latter may reduce rural supplies of forest services as well as incomes from those who live off the forest. This income loss may be very significant.
- Controlled clearing of natural forests for farm or grazing land as part of a sustainable long-term land use strategy. The question of the cutting rate is critical. If the rate is greater than the local capacity to use the wood, or sell it into commercial markets, the surplus will be burned as "waste".
- Forest protection and conservation including the protection of wildlife areas
- Increased efficiency in forest management, and harvesting,

Bioenergy from Forest Waste

Energy production from forest products (the bio-energy option) will lead to a reduction in carbon emission by substituting the wood derived from renewable sources for other products particularly fossil fuels. Fossil fuel substitution with biomass derived from sustainably managed renewable resources, will: (i) delay the release of carbon from fossil fuel until it is needed sometime in future; (ii) increase and maintain carbon in sinks.

It has been assumed that in order to produce 45 tonnes of timber 55 tonnes of waste is created, in the form of sawdust, treetops and branches, and is left to decay, burnt on site or collected as woodfuel, hence emitting greenhouse gases. These wastes can be used sustainably as fuels into the turbines to produce electricity. COMAP has been used to make this analysis for the Sao Hill Forest with the main objectives of:

- Estimating the potential for bio-energy technology-based bioelectricity generation using the by-products of Sao Hill Sawmill, given the land availability and the conversion efficiency;

- ♦ Estimating the potential for fossil fuel electricity substitution through the generation of bioelectricity; and
- ♦ Determining carbon emission avoided and sequestered or stored in soil, detritus and standing vegetation.

3.8.2 Ranking of Mitigation Options in the Forestry and Land-use Sector

A comprehensive mitigation analysis process (COMAP) in the forestry sector have been applied in Tanzania to rank specific mitigation projects in the forestry sector and includes an analysis of the cost effectiveness of such projects. Figure 3.3 shows the result of the carbon pool created by the various forest projects with the associated costs in the form of a cost curve. For comparison purposes the project with the largest amount of carbon pool was selected, pending a comparison of the costs and other social aspects.

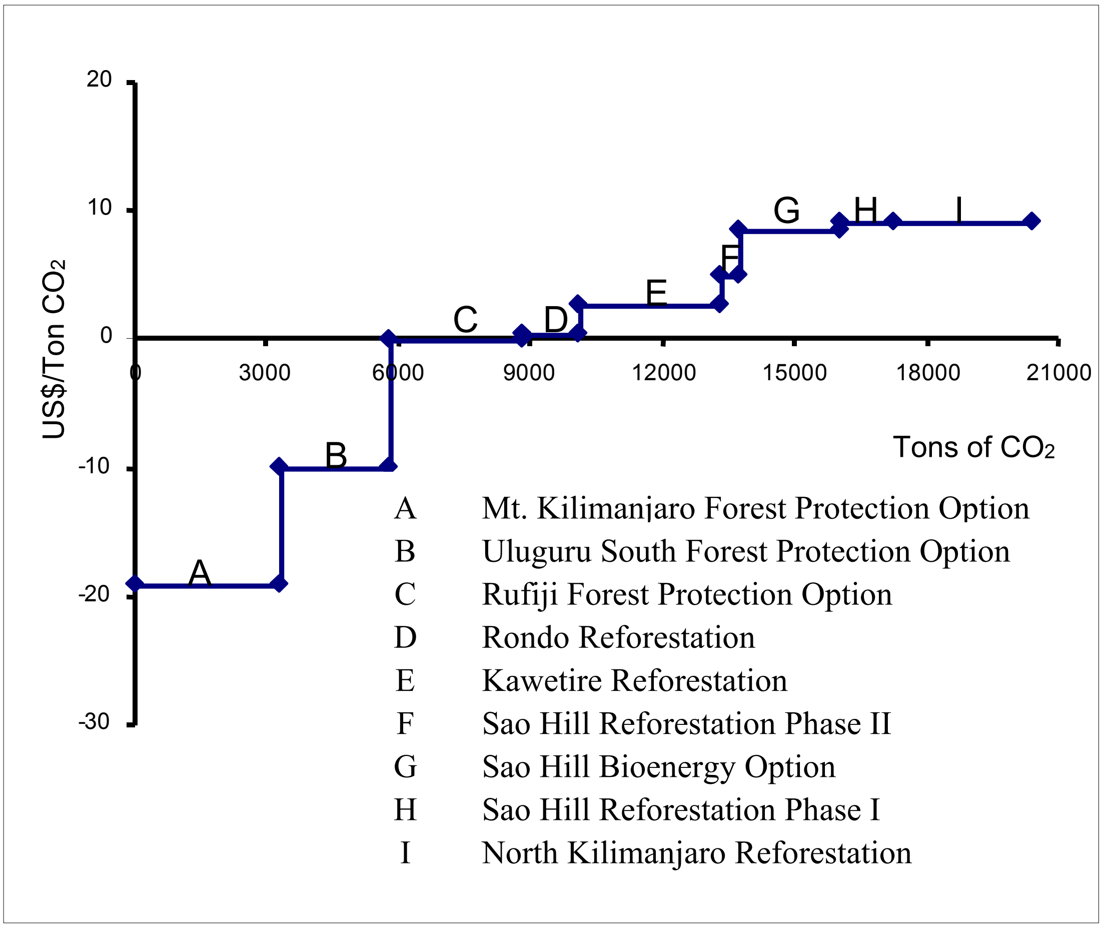

Figure 3.3: *Cost Curve for Forestry Mitigation Options*

In figure 3.3 above it can be noted that the two forest protection options of Mt. Kilimanjaro and Uluguru South are negative cost (win win) options meaning that the costs of the mitigation options are lower than those of the baseline. This may be due to the benefits associated with the mitigation options via forestry products, evaluated in monetary value are more than the mitigation costs. These projects have a high capacity of carbon sequestration compared to, for example the Kawetire reforestation and Rondo reforestration, which are positive cost options, but with lower sequestration potential.

3.9 MITIGATION OPTIONS FOR THE AGRICULTURE SECTOR

Since mitigation analysis has to incorporate technological developments and efficiency in production, it is intended to link these with scenarios in national development plans, as well as the national sectoral policies. The National Action Plan on Climate Change is also being developed on the basis of these findings. It is anticipated that this will facilitate the evolution of implementable projects and programmes to facilitate the mitigation of greenhouse gases.

3.9.1 Reduction of Methane Emission in Crop Production

The following options, which are arranged in order of priority, are recommended:

(i) Irrigation water management;
(ii) Use of improved cultivars and other cultural practices; and
(iii) Nutrient management

3.9.2 Reduction of Methane Emission in Livestock Production

Three main options are recommended in order of priority:

(i) Improved nutrition

Improved nutrition through the use of better pastures, feed supplementation and reduction in stock numbers/destocking have multiple benefits i.e., reduced land degradation due to overgrazing, improved productivity in traditional livestock and reduced methane emission. Greater efforts should be focused on further research, demonstrations as well as the creation of awareness among pastoralists.

(ii) Improved breeding

It will require a lot of effort to make pastoralists understand the consequences of overstocking to the natural environment as far as other land uses are concerned. This option would require concerted efforts to be undertaken by the various stakeholders to remove/reduce the existing barriers.

4: IMPACT OF CLIMATE CHANGE AND VULNERABILITY ASSESSMENT

4.1 OVERVIEW

Tanzania has undertaken an assessment of its vulnerability to climate change. The assessment has also been made possibilities of adaptation to climate change impacts. The main objectives of the assessment have been;

- Identification of areas of potential vulnerability to climate change of natural resources and ecosystems;
- Assessment of the impact of climate change in economic sectors of national development;
- Evaluation of policy options to reduce vulnerability to impacts of climate change;
- Analysis of the feasibility, viability and costs of alternative options; and
- Creation of awareness to public on the impacts of climate change

The assessment has included the following sectors; development of climate change scenarios, Forestry, Agriculture, Rangeland/Livestock, Coastal Resources, Biodiversity and Wildlife, and Health.

The United States Country Studies Programme and the Global Environment Facility and UNEP have supported the study on the vulnerability to climate change impacts. The Centre for Energy, Environment, Science and Technology (CEEST) conducted the studies.

Detailed vulnerability assessment studies have been carried out using climate change scenarios developed in 1994 by CEEST. Scenario development was done using General Circulation Models (GCM) developed in Canada, the United States of America and the United Kingdom. These are UK 89, CCCM, GFD3, GFDLOI and GISS. Base climate data for the years 1951 to 1980 and monthly data from the best GCM were used to create base scenarios. This period is considered to be a representative of the present day or recent average climate in the country. The length of the period encompasses a range of climatic variations including anomalies such as severe drought and extremely wet periods. To set the best GCM estimator a statistical method was employed to complement the graphs. The resultant 30-year climate scenarios form the basis for assessing vulnerability impacts on the above mentioned economic sector.

4.2 ANTICIPATED CLIMATE CHANGE

The best GCMs for different parts of the country were found to be UK89 and GISS for temperature data and UK 89 and GFD3 for rainfall data. When the whole country is taken as an entity the best estimator for the two variables was the CCCM-model.

The scenarios reveal that there will be an increase in mean daily temperature as well as in the temperature of the warmest and coolest months. Mean daily temperature will rise by 3.5^0C throughout the country. The increase in temperature would be more during the cool months of June, July and August than during the warm months of December, January and February. The difference between the two periods being about 1^0C on average. One of the scenarios developed was that of doubling of CO_2 concentration in the atmosphere (2 x CO_2). At the equilibrium level of $2xCO_2$ the annual temperature increase for different parts of Tanzania is expected to range from 2.1^0C in the north-eastern parts to 4^0C in the Central and Western parts of the country. The increase in annual temperature over the whole country is between 2.5^0C to 3.0^0C in the warmest months of December and February and between 3^0C to 3.9 ^0C in the coolest months of June to August.

The scenarios also indicate that there will be increased rainfall in some parts while other parts will experience decreased rainfall. The areas with two rainfall seasons i.e., the north eastern, the north western, the Lake Victoria basin and the northern part of the coastal belt would experience increase in rainfall for both seasons ranging from 5 percent to 45 percent. The other areas receiving unimodal rainfall pattern i.e., the southern, southwestern, western, central and eastern parts of the country will experience a decrease in annual rainfall by a range of between 5 percent and 15 percent. These areas will experience an increase in rainfall during the long rains and a decrease during the short rains. The southeastern parts are likely to experience an increase in annual rainfall by a range of between 5 percent and 45 percent.

4.2.1 Impact on Water Resources

Climate change causes variations in rainfall patterns and soil moisture due to changes in mean temperatures and affects river runoff. In assessing the impacts of climate change to the water resources the major factor considered has been rainfall. Regions with increased precipitation will experience increased runoff while the reverse will be observed in regions with decreased precipitation. Changes in runoff of three major rivers in the country, which have greater economic importance, have been analysed. These are the Pangani, Ruvu and Rufiji rivers (see their catchment areas in Figures 4.1, 4.2 and Figure 4.3 below).

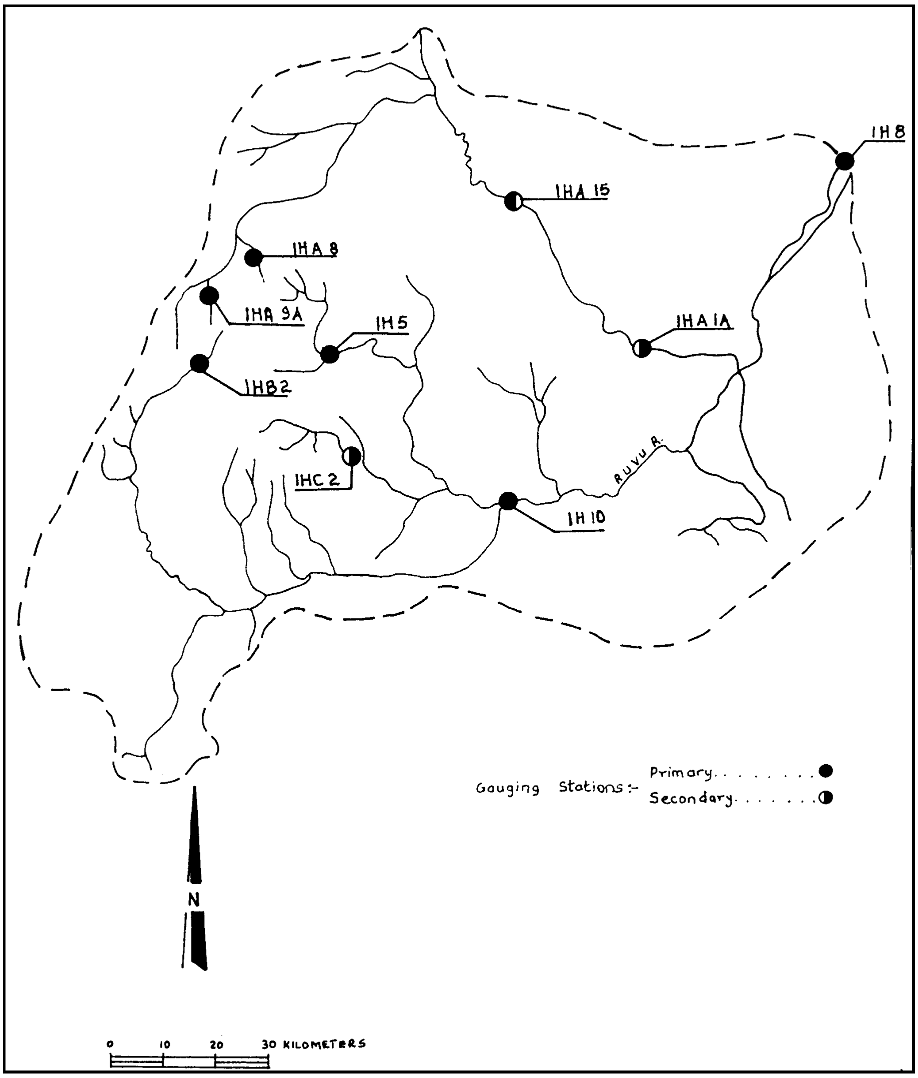

Figure 4.1*: Ruvu River at Dar es Salaam/Morogoro Main Bridge (Station No. IH8)*

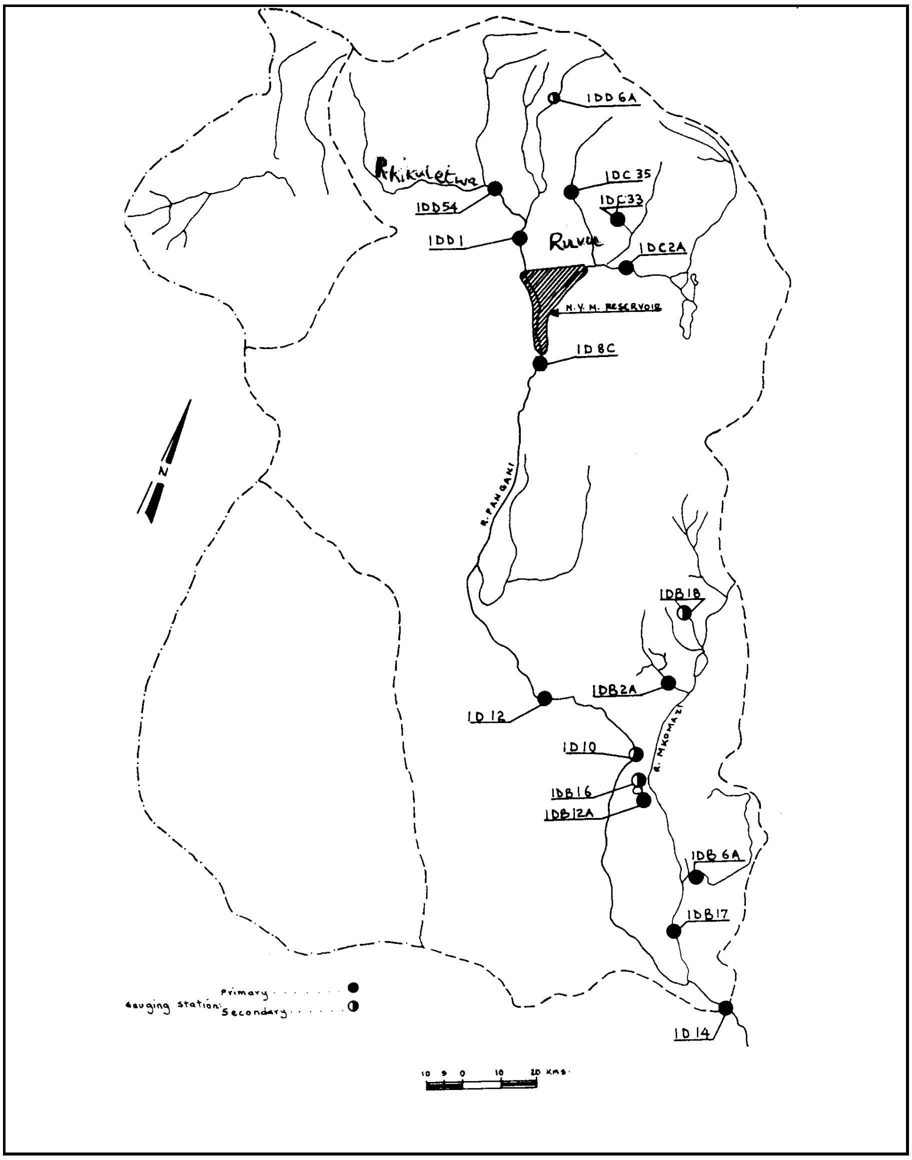

Figure 4.2: *Pangani River at Korogwe (Station No. ID14)*

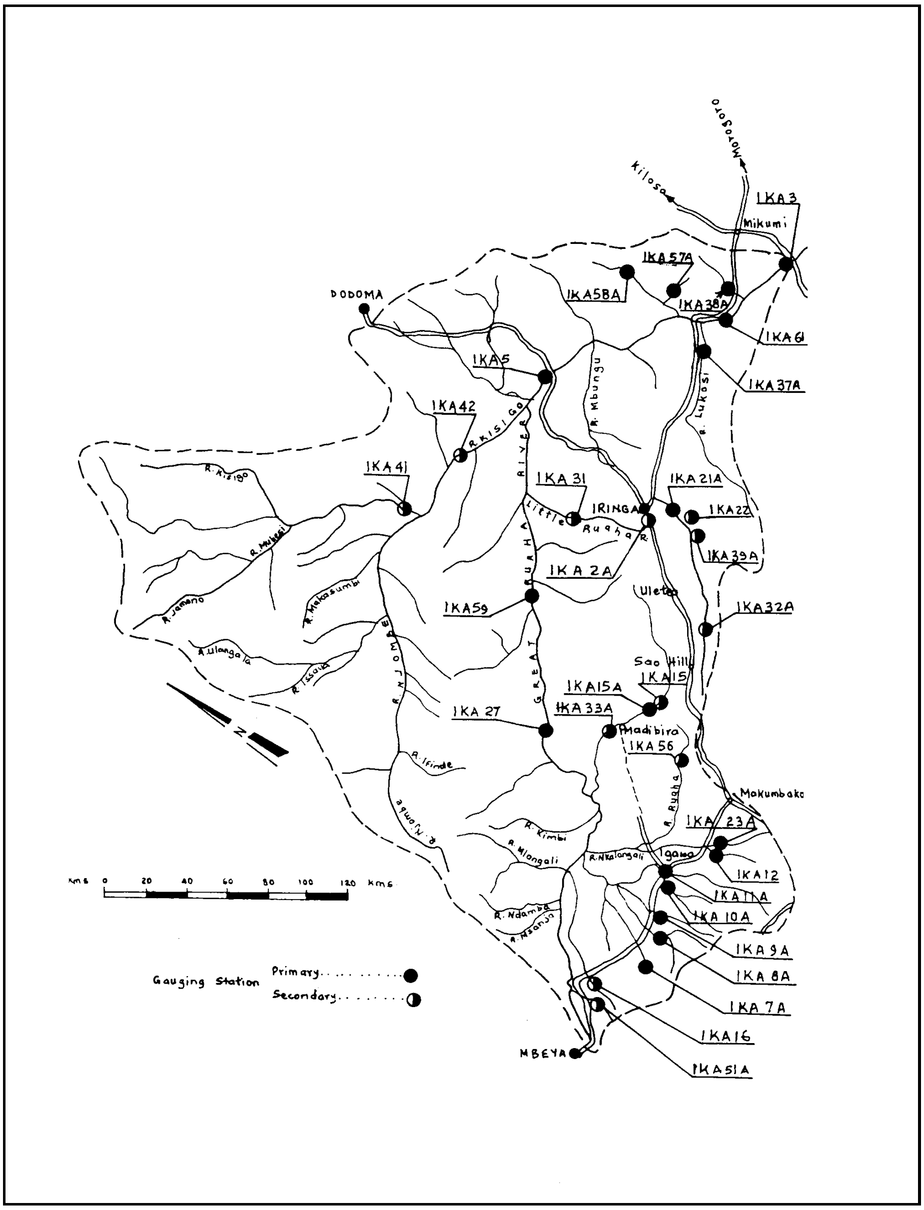

Figure 4.3: *Great Ruaha River at Kidatu (Station No. IKA3*)

With an increase in temperature of between 1.8^0C to 3.6^0C in the catchment areas of River Pangani situated along the coastal areas of the north and north-east, and with the variations in rainfall in those areas, the study estimates that River Pangani's annual flow would decrease by between 6 percent and 9 percent. Also, temperature increase in the Ruvu river basin ranging between 2.1^0C to 4.3^0C coupled with decreased rainfall in the coastal areas will decrease the river's annual runoff by 10 percent. Due to low temperature fluctuations of between 3.3^0 and 4.6^0C and an increase in annual rainfall in the southeastern parts as well as during the long rains of other parts in the catchment areas, the river flow will increase by between 5 percent and 11 percent. The potential for heavy flood damage increases in the long rainy period i.e., from March to May due to a flow increase in Rufiji River.

Reduced runoff of Pangani and Ruvu rivers, which are economically important for supplying water and hydro-electricity to major towns, where industrial activities are highest in the country, would adversely affect socio-economic activities in the country. The five regions supplied are

Dar es Salaam, Coastal, Tanga, Kilimanjaro and Arusha. The two vulnerable rivers supplement water for lowland small-scale rain fed rice cultivation. As rainfall in these two river basins would decrease, it would increase the water use demand thus water availability for agriculture would become uncertain. Floods on River Rufiji caused by increased rainfall during the long rains would cause damage to major hydropower stations in the country, farms along this river basin and human settlement. This river houses Mtera and Kidatu hydropower stations, which produce 80MW and 200MW respectively.

Adaptation responses entail water demand and supply management to increase sources of water supply by constructing reservoirs along rivers Pangani and Ruvu as well as utilizing water-saving technologies; applying various conservation measures and augmenting water supply with the development of groundwater wells. Construction of reservoirs and the undertaking of inter-basin transfers from River Rufiji which, it is predicted will be positively affected by climate change) to Rivers Pangani and Ruvu, which have shown reduced outflows, requires heavy investments and thus such measures are incorporated in the long-term programme of the National Climate Change Action Plan. Other measures under the supply management serve both the sector objectives and the anticipated adaptation responses of this sector and are relatively less costly and hence form the short and medium term programme.

4.2.2 Impact on Crop Production

As explained above the climate change scenarios have predicted changes in rainfall patterns and distribution as well as increase in temperature in various areas of between 2^0C and 4^0C. In areas where rainfall will increase the leaching of nutrients, washing away of topsoil and water logging would affect plant development and thus affect plant growth and yield. Climate change is bound to favour the occurrence of diseases and insect pests due to both increased temperature and rainfall. In such instances, farmers are likely to use more agrochemicals and disease resistant cultivars, which will increase costs. In general, changes in climate will shift the agro-climatic zones. For areas that will get less rainfall due to the doubling of CO_2, irrigation will be required to substitute for moisture losses due to increased evapo-transpiration and thus drought resistant varieties would be required more than at present. Irrigation in such conditions is likely to be expensive because of reduced river runoff and the vulnerability of shallow wells, which necessitate the development of deep wells instead.

Impact of climate change on crop production has been studied using relevant regression models on coffee and cotton; while the CERES model has been used to assess impacts on maize production. Daily weather data observed for the 1950-1980 period has been used in the General Circulation Models (GCMs) to predict temperature and rainfall variations at single and double CO_2 conditions; the resulting figures have been adjusted by modifying the ratio or differences. The climate change scenarios have subsequently been used to run plant models (CERES and GCMs) for different locations where such crops are grown in the country. Cotton is grown in the western, northern, coastal and southern areas of the country. These areas comprise of Mwanza, Shinyanga and Kagera (Lake zone); Kigoma, Tabora (Western zone); Coast and Morogoro (Coastal Zone); Arusha and Kilimanjaro (Northern Zone) and Mbeya in the southern areas.

Cotton

To assess the impacts of climate change on cotton production two representative stations with adequate data have been selected. These stations are located in Mwanza and Morogoro Regions. In the studied areas rainfall is predicted to increase by 37 percent (Mwanza) and decrease by 7 percent (Morogoro). The increase in temperature at $2xCO_2$ is on average 2.7^0C in the studied areas. This increase falls within the optimal limits (18^0C to 30^0C) hence will have no impact on cotton growth. Results show that the area where rainfall will increase yield will also rise by 17 percent. In areas receiving less rainfall the yield is expected to drop by 17 percent. Increased rainfall will also favour the greater occurrence of pests and disease.

Coffee

In order to assess the impact of climate change on coffee production, two areas which represent the major producers in the north-eastern (Lyamungo) and southern parts of the country (Mbozi-Mbeya) were selected. At $2xCO_2$ the temperature increases between 2^0C and 4^0C in the two areas. Also, the rainfall increase is by 37 percent in the north-eastern and the decrease is by 10 percent in the southern parts. Since the increase of 2^0C in both areas is within the optimal values for coffee growth then the major determining factor will be the rainfall. An increase in rainfall will imply an increase in the yield. In the southern areas the decrease in rainfall is minimal and will not affect the yield. The yield will increase by an average of 17 percent in each area. These results take into account the effect of the increase in pests and diseases due to increases in temperature and changes in precipitation in these areas. Increased pests and diseases would reduce yield by 20 percent on average. An increase of 4^0C in those areas would significantly reduce coffee production. At this increase in temperature (4^0C) in the southern areas, where annual rainfall at 2 x CO_2 is predicted to decrease during short rains, irrigation would need to be encouraged to supplement the effect of reduced rainfall and the loss of moisture. Otherwise, drought and disease resistant coffee varieties will need to be developed and farmers sensitized to use them if coffee is to remain a major cash crop in such areas. Coffee is likely to be grown successfully where rainfall will increase i.e., in the northern, north-eastern and south-eastern parts.

Maize

Increases in temperature in maize growing areas and reduced rainfall will affect maize growth and yields due to an increase in the moisture loss and a reduced growth period. Farmers currently cultivating maize might decide to stop growing it because it is difficult to control the effects of higher temperatures and although rainfall could be supplemented by irrigation, this would be very costly to them. The CERES maize model suggests that maize yields in all zones studied are higher under baseline climate, relative to future climate change conditions. The average yield decrease is by about 33 percent over the entire country. Yield reduction in several areas (in brackets) is as follows: central (84 percent), north-eastern highlands (22 percent), Lake Victoria basin (17 percent) and southern highlands (12 percent).

Increase in temperature and rainfall in some parts of the country as mentioned above would raise occurrence of pests and diseases. That means farmers have to adhere to improved agronomic practices. There would be a general change in the cropping and a shift in the agroclimatic zones and hence a demand for better crop management and development approaches. Further work on the impacts of climate change on other crops should not wait until such effects have occurred.

4.2.3 Impact on Grasslands and Livestock

The results of GCMs shown above were applied together with expert judgment to predict the impact of global warming on animal diseases and pests, plant association and distribution and productivity of the plant associations. There are both direct and indirect effects on plant productivity as a result of an imbalance between rainfall, temperature and evaporation. These variables affect productivity and reproduction in plant species and therefore the composition and distribution of the latter over the landmass.

Moreover, areas that receive low precipitation like the central and coastal zones of Tanzania do not have an equal probability of vegetation cover conservation as those that would receive increased precipitation i.e., the northern, north-western and north eastern. In such cases, most of the plant associations are in a transient state. In semi-arid areas, plant species are less tolerant and therefore plant associations are either slowly being replaced by the more tolerant associations or complete replacement was assumed. The study shows that plant species associations at 1xCO2 and 2xCO2 climatic conditions will respond differently to the phenomenon. In areas where rainfall will increase as the CO_2 doubles, the carrying capacity will rise for example, in the northern north-western and north-eastern parts of (Kigoma, Mwanza, Musoma and Same) and in some parts of the southern areas i.e., in Iringa.

The assessment on the vulnerability of grassland and livestock to climate change impacts in Tanzania reveals changes in foliage associations and a shift in foliage species composition with the most palatable species having been grazed out. These will continuously be replaced by more climate tolerant species and the overall carrying capacity of the rangeland would be low due to variations in rainfall, temperature and evaporation as CO_2 doubles in the atmosphere. Surplus foliage would prevail in areas of increased precipitation; however as plants lignify upon reaching maturity, crude protein content would be lowered. This would result into poor performance of the grazing animals and poor milk and meat production would also prevail. Food supplementation with rich protein feeds would be necessary. Such conditions coupled with incidences of pests and diseases would force farmers to adjust their grazing habits and management to ensure livestock have enough grazing all year round consistent with the grassland resources. If anticipatory adaptive measures are not taken into account early enough due to prevailing uncertainties on impacts and the rate of occurrence, the reactive adaptive measures taken by farmers would result into huge economic losses. Environmental degradation would also increase as farmers strive to find their own solutions and these might not be affordable when global warming at $2xCO_2$ becomes a reality.

4.2.4 Impact on Coastal Resources and Structures

The coastline of Tanzania is about 800km long, extending from Umba River in the north (4^0 7'S) to Ruvuma River in the south (about 10^0S). The coastline has a varying width that varies, ranging from 20km to 70km, and gradually rising to a plateau. The main features of the coastline are mangrove forests and swamps, corals, seasonal swamps, cliffs, sand and mudflats, rock outcrops, scrubs, palms, tidal marshes, salt works, woodlands, thickets, sisal estates and cashewnuts. The main rivers entering the Indian Ocean from the coastal belt are Pangani and Umba in the north, Ruvu and Rufiji Rivers in Dar es Salaam and Coast Regions, and Matandu and Mbwemkuru and Ruvuma rivers in the southern coast. The main Islands along the coastal belt are Pemba and Unguja to the north and Mafia Island in the south. Other small islands are Mbudya, Pangavini, Bongoyo, inner and outer Nyakatombe, Kendwa, inner and outer Sinda. A high population and vigorous economic activities including tourism, industry, subsistence agriculture, mining and fisheries characterize the coastline. Marine fisheries constitute 25 percent of the total fisheries catch by weight in the country. It is estimated that the coastal population based on the 1988 population census is 3.8 million, which represents about 16 percent of the total population. The coastline of Tanzania is shown on Figure 4.4 below

Based on sea level rise scenarios developed by IPCC in 1990, a study to assess the impacts of global warming on coastal resources and structures was undertaken between 1994 and 1996. The analytical approach was applied to estimate the loss of coastal resources and infrastructures. Aerial videotaping was done for part of the coastline to record useful information such as the relative topography, physical structure, geological information, types of coastal environment, infrastructure, land use practices and population distribution which are required in the assessment of impacts. Ground trips were made to few representative samples of the coastal resources and structures to gather more information needed in the study.

Briuun's rule (Briuun, 1992) was applied to determine land loss by erosion caused by a sea level rise of 0.5m and 1.0m. A comprehensive evaluation of the economic consequences due to a rise in the sea level was not done due to limited financial resources. An attempt was made to evaluate loss or damage to important infrastructures along the coastline of Dar es Salaam. The important structures found were beach hotels, training institutions, beach clubs, roads, schools, hospitals, offices and fish landing sites and markets. Since global climate change is likely to increase the strength and frequency of tropical storms, an estimation of the loss of structures was done for a storm surge of 5 metres.

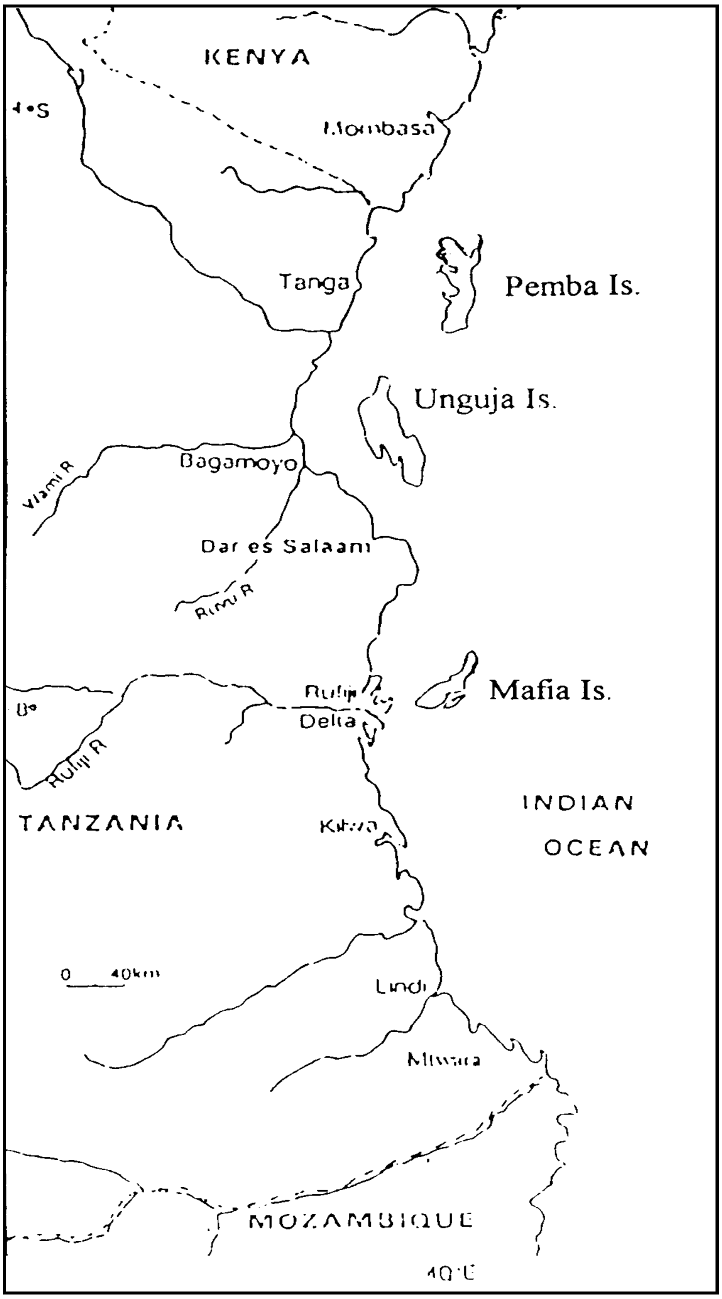

Figure 4.4: *Map Showing the Coastline of Tanzania and Main Islands*

The results showed specific areas most vulnerable in each region located along the coast i.e., Moa (Tanga region), Salale and Mbwera (Dar es Salaam/Coast Region), Nangurukuru and Mnazi bay (Mtwara and Lindi). In each region the areas to be inundated were established for both sea level rise of 0.5m and 1.0m. Mangroves are the most vulnerable resources followed by sand and mud flats. Dar es Salaam and the Coast areas are the most vulnerable while Tanga is the least vulnerable area. In Dar es Salaam and Coast region a total of 14,757 ha and 29,485 ha will be inundated for a sea level rise of 0.5m and 1.0m respectively; in Tanga the areas cover 2,022 ha and 4,045 ha and in Mtwara and Lindi the inundated areas are 7,922 ha and 15,855 ha for the sea level rise of 0.5m and 1.0 metre respectively.

Total land loss is estimated to be 247 square km and 494 square km for the sea level rise of 0.5 metres and 1.0 metre, respectively. Out of 494 square kms, mangroves cover 258 sq kms and sand/mud covers 105 sq km. Table 4.1 below shows areas of major coastal features, which will be inundated along the Tanzania coastline under both scenarios. The values have an estimation error of 5 percent.

Table 4.1: *Area (km^2) to be Inundated Along the Coastline of Tanzania by Sea Level Rise Scenarios of 0.5 metres and 1.0 metres*

Coastal Feature	Tanga	DSM/Coast	Lindi/Mtwara	Total
Mangroves	21	157	80	258
Sand/mud	9	39	57	105
Seasonal swamps	1	38	1	40
Tidal marshes	-	32	3	35
Salt Pans/works	-	28	-	28
Total	**31**	**294**	**141**	**466**

Along the Dar es Salaam coastline the estimated loss of important structures is estimated to cost Tshs.49,83 billion and Tshs.85.97 billion for a sea level rise of 0.5 m and 1.0 metre respectively. The vulnerable structures are as mentioned above. This estimation on economic loss has an error of 10 percent. Loss by a storm surge of 5 metres is Tshs.223 billion. Sea level rise would also cause salt-water intrusion in Tanzania's aquifers and deltas like the Rufiji delta. Therefore it has been suggested that is important to protect vulnerable areas particularly population centres, economic activities and natural resources.

4.2.5 Impact on Forests

Tanzania is estimated to have about 44.5 million ha of forests and woodlands, which is about 50 percent of the total land area of 89 million ha. Of this area, about 1.5 million ha are closed forests and mangroves, and about 43 million ha are open woodlands. Plantations occupy about 0.15 million ha.

Impact assessment on forest ecosystems has been done using literature reviews, expert judgment and the simulation model approach. Climate data i.e. precipitation and temperature from 83 meteorological points/stations across the country were used to produce Tanzania's natural life zones on a map. Climate change scenarios developed above have been used to predict conditions at single and double levels of CO_2. The Holdridge Life Zone classification model and forest gap models have been applied to develop the potential distribution of vegetation and to assess the effect of different parameters on species composition and productivity, respectively.

The actual Tanzania life zone base map at a single level of CO_2 has been developed using Tanzania's actual vegetation map. The dominant vegetation type in Tanzania is woodland (subtropical dry forest), which covers 78.8 percent of the total land; the remainder are forests (subtropical moist forest), bush-land, grasslands and thickets (subtropical thorn woodland). The vegetation is classified in two regions, i.e., Zambezian and Somali-Masai; these differ in terms of area coverage, species composition and levels of annual precipitation.

The results from the Holdridge model shows that at $1xCO_2$ there are three dominant life zones, i.e. subtropical dry forest, subtropical moist forest, and subtropical thorn woodland. These life zones were established using the best Global Circulation Models (GCMs), which correspond to the real Tanzania vegetation map. At $2xCO_2$ the Holdridge life model predicts potential changes in vegetation, for example, subtropical dry forest and subtropical moist forest life zone classes would change, as CO_2 doubles, to tropical very dry forest, tropical dry forest and tropical moist forest. The model predicts that subtropical thorn woodland currently in existence will be completely replaced. Subtropical dry forest and subtropical moist forest will decline by 61.4% and 64.3% respectively. There will be an increase in tropical very dry forest, tropical dry forest and tropical moist forest, which are likely to replace the current life zones. The Forest Gap Model predicted that some species are more vulnerable to climate change than others, particularly those: that are drought/heat intolerant; with low germination rates; with low survival rate of seedlings; and with limited seed dispersal/migration capabilities.

The expert judgment also shows that there will be changes in forest type, species and distribution as CO_2 in the atmosphere doubles. Different vegetation types will experience changes as a result of temperature and precipitation variation. Examples of such changes are: -

- In the areas with well-drained soils, increase in precipitation and temperature along the Lake Zone and the south-eastern, the miombo woodland would develop into closed woodland and evergreen forest;
- In areas with impeded soil characteristics, miombo woodland would be replaced by wooded grassland, which in severe cases would lead to thickets/bush-land as most of the moisture would evaporate due to the high temperatures;
- In the southern highlands, an increase in precipitation of 30 percent and a general temperature increase would cause wetter upland woodland forest to become afromontane forest/vegetation type;
- In areas where there would be a slight decrease in precipitation and increase in temperature there would be higher evapotranspiration. Woodland forest would be converted into wooded grassland or to thicket/bush-land if conditions become severe;
- In the areas with imperfect-to-good excessively drained soils, where there would be increase in rainfall like in the north and north-eastern areas of Tanzania, the wooded grasslands would change to thicket/bush-land forest due to high evapotranspiration and runoff losses. Drought resistant species would dominate;
- In the southern areas like Mbeya, where rainfall would increase slightly and temperature would rise as CO_2 doubled, the upland woodland forest would remain unchanged, as evapotranspiration would be reduced due to the high altitude; and
- Areas with drought-resistant species like those available in the Central Zone would, most likely remain unchanged, irrespective of temperature increase and a decrease in rainfall.

The assessment also shows that some species are more vulnerable to climate change than others particularly:

- Those with a limited geographical range that are drought/heat intolerant;
- That lie at boundaries of compatible climate regions at heat/drought tolerant limits;
- With low germination rates;
- With a low survival rate of seedlings; and
- With limited seed dispersal/migration capabilities.

The above mentioned characteristics are likely to be found in such a diversified ecosystem implying that the highly fragmented forest or species population are more sensitive to climate change.

4.2.6 Impact on Wildlife and Biodiversity

Tanzania's protected areas cover 38 percent of the total land area. These areas are interspersed within 19 broad habitats that support over 40 million ungulates. Wildlife contributes about 12 percent to the GDP and supplies more than 50 percent of the meat consumed by the communities in surrounding areas. Woodlands and forests cover 50 percent and 11 percent is for smallholder cultivation, large-scale cultivation and other land uses. There are 12 National Parks (NPs), the Ngorongoro Conservation Authority Area (NCAA), 23 Game Reserves (GRs) and 44 Game Controlled Areas (GCAs). There are 310 species of mammals, 1016 species of birds, 273 species of reptiles, and 34 species of swallowtails.

High rainfall in the highlands of the north and south and around Lake Victoria basin, and an equatorial climate, coupled with variation in the topography and the environment, has made Tanzania biologically rich. The NPs are areas designated for tourism, site seeing, camping and photographing and act as buffer zones with human activities and licensed hunting. Some of endangered species in Africa are also found in Tanzania; these include the wild dog, the black rhinoceros, the African elephant and the Nile crocodile.

The ecosystems are composed of the Zambezian phytochorion, Zanzibar-inhumbane mosaic, Somali-Maasai, Afromontane and the Lake Victoria mosaic. This classification gives Tanzania 7 biogeographic regions with 19 broad habitat types. Tanzania has the highest number of habitats in sub-saharan Africa, the most wide-spread being miombo woodlands, Acacia-dominated savannas and woodlands, Acacia-comiphora thornbush, coastal forest, moist savannah/forest mosaic and montane forest. Tanzania is a mega-diversity country along with other countries such as the Democratic Republic of Congo, Brazil, Indonesia and Madagascar. Animal population has been fluctuating during the 1980s and 1990s mainly due to illegal hunting, predation, diseases, poaching, drought and cultivation. The most affected species include the elephant, buffalo, wildebeest and black rhino.

An assessment of climate change impact on wildlife and biodiversity in Tanzania has been done using both expert judgment and model simulation at conditions of single and double levels of CO_2. The assessment has also made use of climate change scenarios. Impacts have been assessed on parasites and diseases, foliage dry matter (DM) production, animal biomass production and habitat vulnerability of five ungulates in a specific National Park (Mikumi). Mikumi National Park has been chosen because of its proximity and ecological significance. This National Park is covering 3,230 square kms and is composed of Zambezian Woodlands (miombos) and Zambezian grasslands (flood plain grasslands). A Habitat Suitability Index (HSI) model has been applied to study the habitat vulnerability for the dik-dik, elephant, rhinoceros, impala and giraffe at the Park.

Ordinary parasites and diseases do not cause problems in wildlife because animals adapt over time. Wildlife usually acts as reservoirs for many parasites and diseases. However, the occurrence of new parasite/diseases can kill a large number of animals like the case of rinderpest in Tanzania in 1989, which was later, eliminated through the vaccination of cattle. Wildlife is a reservoir of sleeping sickness and nagana diseases, which affect human beings and domestic animals, respectively. These diseases are fatal and would drastically reduce agricultural productivity if left unchecked/untreated. Ticks are widespread and are locally abundant vectors of livestock diseases. Both vectors have been assessed in order to study the probability of their occurrence when atmospheric CO_2 concentration is doubled.

The analysis leads to the following results:

i. According to the UK 89 model, as precipitation increase simultaneously vegetation cover will be enhanced in the Lake Victoria basin, the north and northeastern zone and in Mikumi National Park. The number of breeding grounds for pests and locusts will also increase, as will incidences of ticks. In general, more diseases are likely to prevail;

ii. In the coastal, southern and western areas where precipitation has been predicted to decrease, rangeland conditions will be extended and the dry savanna will be free of parasites. The quality of the grazing will be improved, as evapo-transpiration will pull up soil minerals to root zones for use by the plants;

iii. Species that are vulnerable to drought will pave way for those that are more drought resistant. In this process, there will be loss in biodiversity. Such changes would be conducive to wildlife, as most of them are adapted to arid grazing conditions;

iv. Increase in temperature by 2^0C to 4^0C would alter the distribution of the agro-ecological zones. Areas that are used to grow perennial crops would be suitable for annual crops; warming would tend to accelerate plant growth and hence reduce the length of the growing season;

v. The negative effects of doubling of CO_2 would generally affect wildlife in Tanzania by affecting the availability of the foliage. This would influence the animal biomass in the protected areas and subsequently the cropping intensities.

4.2.7 Impact on the Health Sector

Malaria is the major public health problem in the country. Malaria, prenatal mortality and AIDS are the three largest causes of the loss of lives. According to 1997 data, malaria accounts for 16.67 percent of all reported deaths in Tanzania while prenatal mortality accounts for 13.34 percent of all deaths. Malaria is also one of the leading causes of morbidity in all regions of Tanzania, ranging from 24.4 percent in Rukwa region, to 48.9 percent in Dar es Salaam. Fighting Malaria in Tanzania, like in many developing tropical countries, is difficult due to a number of technical and non-technical reasons. The reasons include, among others:

- The growing resistance of the malaria parasites to antimalarial drugs i.e. chloroquine and amodiquine;
- Malaria vectors developing resistance to some insecticides such as DDT;
- Mosquito control measures have become less due to a lack of resources;
- Poor sanitation in squatter areas which increases the breeding sites and;
- Improper environmental management during mining of sand and quarrying in peri urban areas.

Malaria transmission occurs throughout the year, greatly influenced by high temperatures and humidity, with the highest transmission coming after the rainy season. Low coastal belts and the shores of Lake Victoria have the highest transmission. Recently, malaria has been observed to occur even in high altitude areas like Kilimanjaro and Arusha (the north eastern zone) and Iringa (the southern highlands). Climatological factors have a considerable influence on mosquitoes and thus on their survival and control.

The malaria vectors found in Tanzania are *Anopheles gambiae* and *Anopheles funestus,* and there are four species of malaria parasites found in the country namely *Plasmodium falciparum*, *Plasmodium malarie, plasmodium ovale* and *Plasmodium vivax*. Of the four species found in the country, the predominant species is *Plasmodium falciparum*, which contributes between 80 to 90 percent of the malaria infections in this country. Plasmodium malaria contributes 10 to 15 percent and the rest contribute 5 percent. The mosquito vector survives best between 12^0C and 35^0C with the optimum survival conditions being between 25^0C to 30^0C and a relative humidity of 60 percent.

Climate change is expected to affect the ecology of malaria in a given geographical location. The ecosystem of malaria can be divided into the three sub-systems namely the climate subsystem, the human subsystem and the mosquito subsystem. Climate change will most likely lead to an increase in incidences of malaria diseases across the country. Areas, which would receive more rainfall than now, would attract vectors and have a positive influence on their survival. The costs of malaria control would increase depending on vector resistance and their distribution. An assessment of the impact of climate change on malaria has not been undertaken due to limited resources. A detailed assessment of impact to malaria diseases is highly recommended because Tanzania is a tropical country where malaria (a climate-linked disease) ranks first as a killer disease.

5: ADAPTATION MEASURES

Adaptation is defined as adjustment in behaviour or the economic structure that reduces the vulnerability of society to climate change, in all climate systems. Adaptation is necessary because:

- Reduction of GHG emission especially CO_2 from human activities is difficult to achieve;
- Early anticipatory adaptation will prove less costly than forced adaptation measures if delays continue;
- Climate may change more rapidly than the General Circulation Models suggest.
- Immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events;
- Immediate benefits can be gained by removing mal-adaptive policies and practices; and
- Climate change brings opportunities and threats and that future benefits can result from climate change.

In this chapter a summary of possible measures for adaptation to the effect of climate change in Tanzania is presented. Some measures have double benefits, achieving the objectives of the sector as well as mitigating the effects of climate change impacts development. Less costly measures can be considered for implementation in the short-term and medium term programme while those demanding higher investment for further research can form part of the long-term programmme. Research and Development for technological advancement will be implemented during the short-term to medium term programmes. Suggested below are adaptation measures for each sector.

5.1 THE WATER SECTOR

Climate change will have an adverse impact on water supply in Tanzania. In order to alleviate the situation, supply and demand management approaches will have to be applied. Supply management entails more capital investment in reservoirs and the infrastructure. This will involve the construction of a reservoir in Ruvu River basin in order to store water that is currently lost to the Indian Ocean. Pangani and Ruvu rivers both will have reduced runoff under climate change because of the temperature increase and reduced rainfall in the catchment areas; hence the importance of having reservoirs to store rainwater. Supply management will involve;

- Development of ground water wells and providing for interbasin water transfers;
- Rainwater harvesting and development of groundwater for domestic use; rainwater harvesting and the development of groundwater are already applied in the country so as to supplement water supplies from rivers. Already, plans are underway to construct two reservoirs in the Ruvu basin;
- Interbasin water transfer from Rufiji Basin to Ruvu River is also being considered.

Demand management will involve:

- Investing in new water-saving technologies and changed user practices. Already some industries are applying cleaner production techniques;
- Water conservation measures at the level of catchment area and end use (protection of the catchment area and the re-use and re-cycling of waste waters respectively).

5.2 THE AGRICULTURE AND LIVESTOCK SECTORS

5.2.1 Agriculture

The doubling of CO_2 will lead to changes in cropping, a shift in the agroclimatic zones, and an increase in pests and diseases. These impacts would demand better crop management and development approaches. In areas where rainfall would be reduced and where temperatures would rise, there would be a shortening of the growth period. Increase in the precipitation on the other hand, would lead to the leaching of nutrients, soil erosion (especially in upland areas) and water logging. The changes in rainfall and temperature will affect both crop and livestock production. Farmers would need to adapt to these changes. If climate change is gradual it may go unnoticed, as most farmers would adjust to other new technologies and management techniques. The proposed adaptation measures for crop production mainly involve in land use and management related changes. Changes in land use involve changes in farmed area, changes in the crop type to suit the changes in climate conditions and changes in crop location. Changes in management require the introduction of the irrigation system and different crop cultivars, improved manure/fertilizer use, control of pests, weeds and diseases, change in planting dates and better exploitation of climate and weather data. The following adaptation measures in the agriculture sector are pertinent:-

- In areas where rainfall has been observed to decrease, like in the southern and central areas, cotton growing would not be suitable. Cotton growing would have to shift to the northern areas where rainfall availability would be better. In such areas it would be advisable to grow drought resistant crops;
- Since some parts of the coffee growing areas like the southern parts will experience reduced rainfall it would be necessary to introduce crop varieties whose maturities varies widely and which have climate tolerance. In this case irrigation will be required to supplement moisture losses caused by raised temperature and reduced precipitation;
- Topsoil and nutrients by leaching in some parts of Tanzania will necessitate the application of minimum and reduced tillage technologies in combination with the planting of cover crops and green manure crops to restore nutrient loss. Mulching is important to coffee plants because it reduces evaporation and improves water retention by coffee plants;
- Current traditional irrigation schemes will require substantial improvement to reduce water loss by evaporation and infiltration;
- Tillage methods and the incorporation of crop residues are other means of increasing the useful water supply for cropping;
- The costs of pests and disease control will rise because their occurrence will increase as temperatures and rainfall increase to favour their growth, survival and distribution; and
- Food programmes and other social security programmes in case there is crop failure need to be introduced to provide insurance against local food supply changes.

5.2.2 Livestock

Adaptation measures for the livestock sub-sector involve changes in management as well as changes in land-uses. Management aspects are adjustment to grazing systems that avoid the destruction of the environment, the planning of animal breeding during the rainy season, better animal husbandry measures and the optimization of livestock production. Land use will involve providing title deeds to pastoral organizations and encouraging rangeland development initiatives. Government policies would need to support livestock keepers to adjust and cope with the effects of changes in climate.

The existing macro economic and sector policies do not take into account the effect of climate change on agriculture. Continued use of these policies without paying adequate attention to the predicted impacts will have adverse impacts on the economy and on socio-economic development. The relevant measures for Tanzania include:

- Decentralization of power to local authorities;
- Private sector reform;
- The initiation of credit facilities for farmers and the strengthening of cooperative unions
- Land tenure system;
- Formation of pastoralists associations and ensuring the availability of adequate facilities to pastoralists who in most cases live in semi-arid areas; and
- Provision of subsidy schemes for crops and inputs

All these are part of the necessary steps required to build the adaptation capacity of agro-pastoralists and pastoralists. Further studies need to be undertaken to assist in improving the policies, plans and strategies of this sector as well as to assess implications of the proposed measures in order to encourage a fast and smooth adaptation process.

5.3 COASTAL RESOURCES

There are three response strategies for adaptation to the vulnerability of coastal resources to a sea level rise. These are; retreat, accommodation and protection. Retreat in this case means the abandonment of the land and structures in vulnerable areas and the resettlement of inhabitants. Accommodation means the continued occupation and use of vulnerable areas, which may involve changes in land use. The building of a barrier wall around the vulnerable areas (protection), especially the population centres, points of economic activities and natural resources is another option.

Protection is the most favourable option. The existing Integrated Coastal Zone Management Programmes and other resource conservation programmes help to build the capacity of coastal communities in participatory land use planning and resource conservation.

5.4 THE FORESTRY SECTOR

Climate change impacts will include changes in vegetation/forests and their distribution, and changes in life zones. Some species will be more vulnerable to climate change than others. Adaptation measures being proposed are:

- Better forest management practices;
- Afforestation programmes in degraded lands using more adaptive species;
- Improvement/change in the use of forests and forest products to reduce tree felling by the application of alternative materials;
- Enhancement of forest seed banks and the development of new plant varieties;
- Encouragement of multiple/diversity management practices in the case of plantations;
- Reduction of habitat fragmentation,
- Promotion of the development of migration corridors and buffer zones; and

- The application of technologies that use other materials instead of wood, for example recycled plastics in the production of furniture will lead to a litter-free environment and conserve trees for environmental purposes e.g. their use as sinks for CO_2. Likewise, greater recycling of waste paper will also reduce the volume of tree logs used to manufacture paper and paperboards.

These measures, to some extent have been implemented as part of sustainable forest management.

5.5 WILDLIFE AND BIODIVERSITY

At 2 x CO_2, as temperature and precipitation change across the country, there would be a change in the vegetation cover, an increase in pests and diseases, an alteration of agro-ecological zones and shorter plant growth period as temperature rises. The availability of foliage will vary depending on the positive and negative effects and this would influence animal biomass and consequently the cropping intensities. In general, there would be a loss in bio-diversity.

The proposed adaptation measures being proposed relate to the development and implementation of management plans for protected and conserved areas. Elements of research and community based management should be considered as paramount in any such management plans. The plan should consider aspects of the buffer zone, habitat and intervention techniques, restoration of degraded land, etc. Other measures include:

- Fire control to minimize degradation and disturbances of the natural vegetation cover/forest and hence the cost of rehabilitation;
- The removal of impediments to migration (e.g. road system) and colonization;
- The preparation of land for the establishment of the desired species;
- Assisted migration;
- The control of alien or invasive species to minimize disturbances;
- The control of diseases, the promotion of irrigation schemes to reduce drought impacts;
- The development of a multi-species animal production system;
- A comprehensive food and water provision programme aimed at ameliorating the impact of drought or famine is also recommended.
- The application of water-saving technologies; and
- Wastewater reuse and recycling and the conservation of catchment areas and wetlands will raise the efficient use of available water and reduce impacts of the drying up of water resources.

Regarding the control of pests and disease, there is need to monitor changes in disease distribution and the expansion of the range of disease vectors as well as to plan their control strategies. A multi-species animal production system reduces the predicted vulnerability to the wildlife sector because of the various cropping options and hence increases resilience when management plans are implemented effectively. Tanzania is implementing management plans for National Parks, conservation areas and buffer zones. Community Based Management (CBM) programmes in the surrounding areas has succeeded in protecting animals against illegal hunting. The destruction of buffer zones has been minimized.

5.6 HEALTH SECTOR

Proposed adaptation measures focus on the control of malaria transmission. Comprehensive malaria control programmes need to incorporate the already known malaria transmission control measures, effectively monitoring the undertaking of relevant special studies and multi-sectoral beneficial actions. The existing malaria control programme needs to be reviewed to accommodate recent research findings and climate change related aspects. Adaptive measures that are known worldwide include making use of an environmental barrier, chemical, and biological barriers and chemotherapy. Each of these measures, each measure has its own significance and no single measure can replace other measures.

Environmental management is directed at reducing or eliminating the breeding sites e.g. through proper drainage, filling, water level management, and the removal of empty containers that provide a good habitat for larval breeding. Environmental manipulation also controls the larval and adult stages e.g. by spraying of the breeding sites/and the flight range with insecticide. In the event where the water has an economic or aesthetic value, elimination through the use of insecticides might not be desirable thus measures like the introduction of predators like fish or the changing of the water salinity may lead to effective control. Multisectoral actions such as the better use of water and land for agricultural improvement and extension are added advantages. There are animal predators such as frogs, fish and ducks, which infest mosquito eggs and larvae while picking on other food.

Table 5.1: *Summary of Vulnerability and Adaptation Options by Sector*

Vulnerability	Adaptation Measures
Agriculture Sector	
Maize Integrating the CERES-Maize model and GCMs showed that maize yields would be lower with a doubling of CO_2 than under baseline climate in all scenarios, as a result of change in rainfall and decreasing temperature.	**Option:** • Increase irrigation to boost maize production in all areas • Grow short-season and drought-resistant crops • Adjust farming areas • Change crop rotation practices • Increase the use of manure and fertilizer • Control pests, weeds, and diseases • Make better use of climate and weather data, weather forecasts, and other management tools
Coffee Simple linear regression models showed that coffee production yields are likely to increase as long as standard agronomic practices are followed.	• Follow standard agronomic practices
Cotton Cotton yields are likely to increase by 17%-169% as long as standard agronomic practices are followed. Yields could decrease by 10%-20% depending on the impact of pests and diseases.	• Follow standard agronomic practices
Grasslands/Livestock Sector	

Increased temperature and rainfall could result in:
• Changes in plant species associations
• A general increase in DM yields
• Favourable condition for ticks, snails, blood-sucking insects and pests; the increased likelihood of infection such as ECF, trypanosomiasis, liverflukes, bluetongue; increased likelihood of locust and armyworm outbreaks
	Reactive adaptation measures:
	• Change land use patterns
	
	Option:
	- Make management changes:
	  • management for proper range use
	  • range management for livestock production
	  • manipulation of range vegetation
	- Make infrastructural changes

	Anticipatory adaptive measures: • Infrastructural development • Research and development • Education of farmers • Input costs and product pricing
Forestry Sector	
Most of Tanzania's land is projected to shift from subtropical dry forest and subtropical moist forests to tropical very dry forests, tropical dry forests, and small areas of tropical moist forest.	• Reduce the rate of deforestation • Protect the existing forests • Introduce new tree species or strengthen the conservation of the existing species • Change or improve the use of forests and forest products
Water Sector	

With higher mean temperatures, runoff is likely to decrease in two basins, the Ruvu and Pangani Basins; runoff is also likely to increase in other basins.	- Supply management: increase capital investment in reservoirs and the infrastructure
	- Demand management: reduce the water demand by investigating new water-saving technologies and changing the patterns of use
	
	- Conservation in the domestic sector:
	  • Reduce the use of water for bathing and toilet flushing
	  • Reuse cooking water
	  • Repair leaks
	  • Reduce use of water for washing cars
	  • Harvest rainwater
	
	- Conservation in the agricultural sector:
	  • Encourage night-time irrigation
	  • Introduce closed conduits
	  • Reuse drainage water
	  • Use waste water/effluents
	
	- Conservation in the industrial sector:
	  • Encourage the recycling of water

Coastal Areas	
Almost Tanzania's entire coastline is vulnerable to either 0.5 m or 1.0 m of sea-level rise. • Land losses are 2090 km^2 for 0.5 m and 2117 km^2 of 1.0 m sea-level rise • Structures at risk in Dar es Salaam are valued at about TShs 50 billion and TShs 86 billion for sea-level rises of 0.5 m and 1.0 m, respectively	• Protect important areas • Construct sea walls • Implement building regulations • Regulate urban growth Protecting the coastline of Dar es Salaam would cost TSh 270 billion; protecting the whole coastline of Tanzania would require TSh 9 trillion.
Health Sector	
♦ Climate change is expected to affect the ecology of malaria in the climate subsystem, and the mosquito subsystem ♦ The study predicts more cases of malaria diseases due to higher temperature across the country	• Control malaria transmission. A comprehensive malaria control programme need to be in place • Making use of an environmental barrier, chemicals, and biological barriers and chemotherapy • Environmental management and Environmental manipulation is directed at reducing or eliminating the breeding sites • Anti malarial drugs are aimed at the various stages of the development cycle of the parasite
Wildlife and Biodiversity	
• As CO_2 doubles in the atmosphere both the potential productivity of plants as well as the potential productivity of ungulates in different protected areas would be reduced in some parts. ♦ The positive effect of 2 x CO_2 would realize an increase in tonnes of DM and thousand tonnes of animal biomass in some areas.	• Development and implementation of management plans for protected and conserved areas. • Community Based Management (CBM) programmes in areas surrounding the national parks and game reserves

6: NATIONAL ECONOMIC DEVELOPMENT AND SECTORAL POLICIES

6.1 DEVELOPMENT POLICY EVOLUTION

Since attaining independence in 1961, the United Republic of Tanzania has been addressing its development process through long, medium and short-term development plans and programmes. These plans and programmes have embodied macroeconomic and sectoral policy objectives and priorities as well as the cross-sectoral issues such as poverty alleviation, population, science and technology and environmental protection.

The Development Plan for Tanzania Mainland (Tanganyika), 1961-1964 was the first post-independence plan whose prime objective was to increase the cash income per head of population and improve the standard of living. That Plan was followed by the First Five Year Plan 1964-1969 (FFYP), which was relatively comprehensive and addressed the long-term issues with the basic objective of bringing about structural change in the economic and social sectors, particularly in agricultural production, industrialization, marketing and distribution. The Second Five Year Plan, 1969-1974, had almost the same policy thrust as the FFYP but adopted a socialist-orientation in attaining the objectives in conformity with the Arusha Declaration (the Policy of Socialism and Self-Reliance) which was promulgated in February 1967, basically shifting from a market-oriented to state-controlled economy.

The Third Five Year Plan (TFYP) 1976-1981 had similar policy objectives as the previous two plans but with the thrust of socialist construction. Specifically, the main objectives underscored the raising of the living standard of the people, self-reliance, the development of collective and cooperative economic activities, and economic cooperation with other African countries. The First Union Five Year Plan, 1981-1986 also had a similar policy thrust.

Since the mid 1970s, Tanzania's economy has been facing a series of shocks, mostly exogenous, that have had an effect on the pace of socio-economic development. The main shocks include droughts, the phenomenal rise of petroleum prices, repercussions of the border war with Uganda, the resource burden following the collapse of the East African Community, the fall in export commodity prices, and most recently, the *El Nino* floods. In an effort to address and avert those shocks the Government, since the early 1980s, initiated and implemented a series of policy measures and programmes, namely, the National Economic Survival Programme, 1981-1982, the Structural Adjustment Programme, 1982-1985, and the Economic Recovery Programme, 1986-1989.

6.2 THE MACRO-ECONOMIC POLICY FRAMEWORK

Since the mid-1980s, Tanzania's economy has undergone fundamental transformation through wide-ranging political and economic reforms and policy actions. The role of the government has been redefined to be that of policy formulation and guidance, law and order, regulatory and public sector support functions; while the private sector has been assigned to undertake production, processing, commercial and marketing functions. The policy thrust of the transformation process is on macroeconomic stability, public sector efficiency, putting in an enabling environment to facilitate the effective participation of all actors in development, and evolving a long-term perspective for the dynamic development of the economy.

The current medium-term planning and budgetary framework underscores the following policy objectives:

- Achieving a real rate of economic growth well in excess of the expected population growth in order to attain real improvement in the living standards;
- Reducing the rate of inflation to below 10 percent;
- Reducing external dependence by creating self-sustained internal and external balances;
- Substantially reducing the role of the public sector in direct involvement in the productive sector and letting the private sector assume the leading role;
- Improving the efficiency of public expenditure by properly utilizing the scarce resources in the priority sectors;
- Undertaking investment in the infrastructure for rehabilitation and development; and
- Undertaking investment in the sectors dealing with human development particularly the health, education, water and environment sectors.

The long-term development perspective plan is embodied in Tanzania's Development Vision 2025, underpinned by the following policy objectives:

- Ensuring economic prosperity and improving the living standards of the people;
- Ensuring economic justice and equity through productive employment and enterprise;
- Promoting and achieving self-reliance, self-sustaining economy and a nation that can effectively cope with changing market and technological conditions;
- Encouraging the transfer of appropriate technologies and human resource development, including the enlargement and development of local scientific and technological capacities.
- Transforming Tanzania from a rural based agricultural economy to a more diversified and industrialized one;
- Promoting, achieving and maintaining national equity and cohesion;
- Optimally utilizing the nation's natural and other resources and balancing an accelerated economic growth with the more efficient management of the environment and the use of the country's natural resources in ways which will ensure sustainability.

6.3 SECTORAL POLICIES

6.3.1 Agriculture

In the medium and long- term perspective, agriculture will continue to play a central role in Tanzania’s economy. Key areas of the economy in which the contribution of agriculture is decisive are the country’s Gross Domestic Product (GDP), export earnings and employment in which the sector accounts for 75 percent and 80 percent respectively. Crucial components of the agricultural sector are food crops, livestock, and traditional export crops whose contribution currently stands at respectively 55 percent, 30 percent and 8 percent of the total agricultural GDP.

Tanzania is endowed with 88.6 million hectares of land suitable for agricultural production, of which 60 million hectares are rangelands ideal for livestock production. Of this total, only 6-7 million hectares are used for rainfed agriculture while 24 million hectares are used for livestock keeping.

Tanzania's agriculture is dominated by some 4 million smallholder households organized in some 8,000 villages with an average holding of less than 2 hectares per household. The most common holding is the homestead or family farm, which is owned and operated individually. Of these farming households, 106,000 practice pastoralism and another 268,000 are engaged in agro-pastoralism. Most of the agricultural activities are performed with rudimentary and low level technology. The use of mechanical power, fertilizers, ago-chemicals, irrigation, improved seeds and modern animal husbandry practices is relatively minimal.

The natural resource base, which includes land and water, is already seriously threatened by unsustainable farming practices and environmental pressures caused by human activities. Although Tanzania is endowed with abundant land and wide ecological diversity, land use is highly constrained by reliability and distribution of rainfall, tsetse infestation and the lack of basic socio-economic infrastructures. At the same time pressures for more fertile land coupled with the demand for household energy, is estimated to account for the loss of about 300,000 hectares - 400,000 hectares of forest cover every year.

The main and ultimate challenge for Tanzania is to improve the well-being of its people whose principal occupation and way of life is based on agriculture and to meet the needs of other sectors. The main policy objectives highlighted in the Agricultural and Livestock Policy, 1997 are the following:

- Assuring basic food security for the nation, and to improve national standards of nutrition by increasing output, quality and availability of food commodities;
- Improving the standards of living in the rural areas through increased income generation from agricultural and livestock and livestock production, processing and marketing;
- Increasing foreign exchange earnings for the nation by encouraging the production and increased exportation of cash crops, livestock products, other agricultural surpluses, including food crops, by-products and residues;
- Producing and supplying raw materials for local industries;
- Developing and introducing new technologies, which increase the productivity of labour and land;
- Promoting integrated and sustainable use and the management of natural resources such as land, soil, water and vegetation in order to conserve the environment.
- Developing the human resource in order to increase the productivity of labour and to improve ability, awareness and morale;
- Providing support services to the agricultural sector, which cannot be provided efficiently by the private sector; and
- Specifically promoting the access of women and youth to land, credit, education and information.

The Government is using the following policy instruments to achieve these objectives in this sector:

- Agricultural research, extension and training;
- The monitoring and evaluation of agricultural development and the identification of new opportunities (products), technologies, markets and the promotion of new production processes;
- The collection and dissemination of market information in order to integrate the domestic markets and make foreign markets accessible;
- The facilitation of the provision of a good infrastructure, especially transport and storage;

- The control of quality, hygienic and sanitary standard;
- The control of vermin, epidemic pests and diseases;
- The provision of an adequate legal and regulatory framework;
- Natural resource management;
- The promotion of institutional structures in the sector; and
- Taxes and subsidies.

Aware of the critical dependence of agriculture on the environmental resources such as land, water, forest and air, the government underscores the imperative need to design agricultural policies that fit in the overall environmental policy which provides guidance for the proper and balanced use of natural resources and defines the sectoral responsibilities in environmental management.

6.3.2 Industry

At independence in 1961, simple consumer goods and agricultural processing for export dominated the structure of the industrial sector. In the pursuit of restructuring the post-independence economy, the government in the early 1970s formulated the Basic Industry Strategy (BIS), which was adopted in 1975. The thrust of the BIS was to raise the degree of the national economic integration by enhancing the intra and inter-sectoral linkages. The enhancement of local value added goods was given priority through the exploitation of the local resource base for raw materials and for the production of intermediate and capital goods.

The implementation of the BIS was limited by resource constraints for investment and infrastructural support. Under the most recent economic reform programmes, the manufacturing sector has been subjected to trade liberalization and demand restraint measures. In the ongoing reform measures, the government is putting into place a policy environment, which is favourable to private sector expansion.

The government is addressing the main challenge of building a strong, diversified and resilient industrial sector, which can produce efficiently for the needs of the people and supply competitively to the world market. The main objectives of the National Industry Policy are to increase industrial output and the share of industry in the overall economy through increased efficiency and increased capacity utilization in existing industries, and the development of new industries in the key sub-sectors. It is envisaged that through appropriate macro-economic policy environment and management private sector participation will be increased and the direct involvement of the government in productive activities will be reduced.

The specific objectives of industrial sector development are the following:

- Increasing the use of domestically available materials;
- Expanding employment opportunities;
- Increasing and diversifying the sources of export earnings;
- Ensuring the best use of resources towards potentially efficient enterprise;
- Protecting the environment from industrial pollution; and
- Enhancing research and the development of technology.

In order to achieve those objectives, the following policy measures and strategies are pursued:

- The promotions of small-scale and medium scale industries for the purposes of increasing industrial output, employment generation, sector linkages and rural industrial development.
- The creation of an enabling environment for private sector participation in investment and production.
- The strengthening of human resource development and technical capabilities to ensure competent engineering, technical and management skills.
- The promoting of clean technologies and environmentally friendly technologies.

6.3.3 Energy

The availability of energy is a prerequisite for the proper functioning and development of all other sectors of the economy, since the energy demand is driven by the requirements of the entire economy. The main challenge is to develop reliable, economically accessible and appropriately priced energy supplies to facilitate the development of other activities in the economy while ensuring environmental sustainability.

The overall policy objective of energy development in Tanzania is to provide an input into the development process of the economy through the establishment of an efficient energy production, procurement, transportation, distribution and end-use system in an environmentally sound manner and with due regard to gender issues. Thus, the principal specific objectives of the national energy policy are:

- To satisfy the energy demand of all sectors of the economy, not only to the productive sectors (i.e., agriculture, industry and mining) but also to the whole country.
- To develop indigenous sources of energy (natural gas, coal, solar, wind, geothermal, hydropower and biomass fuels) to substitute for imported petroleum products.
- To ensure that the existing and expanded supply of energy is environmentally sustainable.

The following policies and strategies are pursued to address the challenges facing the energy sector in the economy:

- Improvement of the availability, reliability and security of energy supply through the rehabilitation of the existing energy systems and the expansion of the power generation and distribution capacity.
- The development of indigenous sources through the further exploration, exploitation, capacity building by training, research and development of technologies, and strengthening of energy information systems.
- Improvement of efficiency in energy chains relating to tariffs, management, maintenance and training.
- The promotion and dissemination of affordable technologies through the demonstration of efficient technologies, and encouraging the participation of the private sector, Non Governmental Organizations (NGOs) and Community Based Organizations (CBOs).
- The promotion of energy development that is environmentally sustainable including environmental impact assessment of projects, afforestation and reforestation programmes, and instituting appropriate legal and regulatory frameworks.
- The promotion of rural electrification and decentralized energy systems.

6.3.4 Transport

The transport sector accounts for about 6 percent of the real GDP and 16 percent of the gross capital formation. It provides vital spatial and sectoral links in the economy and facilitates trade with other land-locked countries in the region. The main challenge is to provide a wide and efficient transport system that covers the entire country and is connected to other countries in the region. The development of the transport system should ensure coordination between and complement the different modes of transport (i.e., road, air, rail and water transport).

The main objective of the transport policy is to provide efficient and effective domestic and international transport services. Other objectives include maximizing both foreign and local revenue generation in the transport sector, and minimizing transport–related environmental hazards. In order to realize these objectives, the government is pursuing the following policies and strategies:

- Limiting the role of the government to policy formulation, monitoring and evaluation and thereby according greater autonomy to parastatals and the private sector;
- Streamlining and strengthening the institutional framework and developing the sector's capacity to plan and enhance inter-modal co-ordination;
- Improving rural and urban travel and transport in order to improve the welfare of the population;
- Encouraging investments by the private sector;
- Encouraging regional cooperation and investment; and
- Encouraging domestic and foreign investments to promote the adoption of new and emerging technologies.

6.3.5 Land

Since Tanzania attained political independence in 1961 there has been the need to have a comprehensive land policy that would govern land tenure, land use, management and administration. The new National Land Policy was enacted in 1998. The main objectives of the policy are the following:

- Promoting an equitable distribution and access to land by all citizens;
- Ensuring that existing rights in land, especially customary rights of small holders, are recognized, clarified and secured in law;
- Setting ceilings on land ownership which will later be translated into statutory ceilings to prevent or avoid land concentration;
- Ensuring that land is put to its most productive use for the promotion of rapid social and economic development of the economy;
- Modifying and streamlining the existing land management systems and improving the efficiency of land delivery systems;
- Streamlining the institutional arrangements in land administration and land dispute adjudication and also making them more transparent;
- Promoting sound land information management;
- Protecting land resources from degradation for sustainable development.

6.3.6 Forestry

The importance of forestry in Tanzania is manifested by the facts that: forest and woodland cover about half of the total land area; about 90 percent of all energy used by Tanzanians is derived from fuelwood. Forestry provides protection for watersheds for various purposes; it also provides timber as well as employment opportunities. The main challenge is to enhance the utilization of the potentials of forests while at the same time managing them to ensure sustainability.

The main objectives of the Forest Policy are:

- Enhanced forest-based national development and poverty alleviation through the sustainable supply of forest products and services;
- Increased employment and foreign earnings through sustainable forest based industrial development and trade; conservation of biodiversity, forest ecosystems, water catchments and soil fertility; and
- Enhanced national capacity to manage and develop the forestry sector in collaboration with other sectors and the international community.

6.4 NATIONAL ENVIRONMENTAL POLICY

The main challenge of development is to promote a quality of life that is socially desirable, economically viable and environmentally sustainable. Sustainable development requires the integration of environmental consideration into economic development policies and programmes. The National Environmental Policy, promulgated in December 1997, provides the framework for mainstreaming environmental considerations in decision-making processes in Tanzania. It provides guidelines on plans and priority actions, monitoring and evaluation. It further provides for sectoral and cross sectoral policy analysis in order to achieve compatibility among the sectors and interest groups and exploit synergies among them.

The overall objectives of the National Environmental Policy are the following:

- Ensuring sustainability, security and the equitable use of resources for meeting the basic needs of the present and future generations without degrading the environment or risking health or safety;
- Preventing and controlling the degradation of land, water, vegetation, and air which constitute our life support systems;
- Conserving and enhancing our natural and man-made heritage, including the biological diversity of the unique ecosystems of Tanzania;
- Improving the condition and productivity of degraded areas including rural and urban settlements so that Tanzanians may live in safe, hygenic, productive and aesthetically pleasing surroundings;
- Raising public awareness and understanding of the essential linkages between the environment and development, and promoting individual and community participation in environmental action; and
- Promoting international cooperation on the environmental agenda, and expanding our participation and contribution to the relevant bilateral, sub-regional, regional, and global organizations and programmes, including the implementation of Treaties.

6.5 ECONOMIC INSTRUMENTS

Economic instruments are incentive systems that are flexible and provide a better understanding of the significance of the people's behaviour and response to different market signals. Economic incentives could be used to influence people's behaviour to achieve social objectives in the most cost-effective manner. Economic instruments provide the means for the internalization of environmental degradation and resource depletion costs in a flexible and efficient way. The objective of internalization is to alter behaviour by reducing the incentives for environmentally harmful activities and enhancing the incentives for environmentally preferable activities.

6.6 CONCLUDING REMARKS

In Tanzania, although some measures have been undertaken which influence the reduction in GHG, many of the initiatives were targeted at achieving other development goals, such as energy efficiency and distribution, and revenue collection. Various sectoral initiatives have implicitly addressed environmental aspects, notably reduction in GHG emission. For instance, the energy sector has benefited from various projects aimed at exploiting renewable energy sources by using energy conservation and efficiency enhancing technologies, such as improved firewood stoves, the use of solar energy for rural electrification, electrical production using biomass.

The transportation sector is estimated to consume around 50 percent of fossil fuels used in Tanzania. The current improvements in road construction are indirectly part of the mitigation options in the transport sector. A lot needs to be done to improve traffic flows to improve vehicle maintenance, and other measures, which lead to an efficient transport system, which simultaneously leads to a reduction in the rate of increase of GHG emissions.

In this chapter, a review has been made of the essential features of the national economic development and other sectoral policies. These policies and the measures adopted to implement broad development objectives have not been formulated with climate change in mind. These policies and measures, however, do also address climate change, an indication that socio-economic and sustainable development need not be pursued at the expense of the environment.

7: RESEARCH AND SYSTEMATIC OBSERVATIONS

7.1 SYSTEMATIC OBSERVATION

Tanzania has several meteorological stations for systematic observation of weather, climate and atmospheric chemistry. The Tanzania Meteorological Agency (TMA) has the role of undertaking and coordinating the above observations. The station network consists of 24 full meteorological stations, 8 atmospheric chemistry, 13 agro-meteorological, 110 climate stations and about 1400 rainfall stations. All of these apart from the climate and rainfall stations are operated by TMA. Other governmental and non-governmental institutions, farmers, schools and individuals operate the rainfall and climate stations on a voluntary basis, and less than 50% of them send in data regularly on a monthly basis.

The main problems affecting the operation of the observing network are lack of equipment, inadequate funding and trained personnel. There is need for equipment for monitoring greenhouse gases and climate observations. These equipments are generally very expensive and most developing countries cannot afford, and some are obsolete. As a result much of the data and information used in the ongoing climate change studies in Tanzania has been obtained from Europe, the United States and Canada.

TMA has staff of 51 Class I meteorologists, of whom 6 are agro-meteorologists, 3 are hydro-meteolorogists. There are 49 class II meteorologists, 72 class III meteorologists and 149 classes IV meteorologist. There are 3 engineers, 16 engineering and instrument technicians and about 160 support staff. There is need for training since it is very expensive.

TMA contributes products and services to many sectors of the economy and disaster management. The present contribution of TMA to agriculture is through the issuing of the daily weather forecast, and the ten-day and monthly bulletins distributed to government offices, all agricultural institutions, and international donor organizations. TMA also participates in the activities of the Crop Monitoring and Early Warning System, which deals with the country's food production assessment. The TMA also participates in the National Disaster Preparedness Committee. The TMA issues early warnings on drought and unexpected weather hazards to agriculture and replies to special requests from decision-makers and agriculturists. In water resources, TMA provides services and products for management and distribution.

The TMA has designed a number of measures in order to meet the increasing demands for meteorological information sources. Among those is the strengthening of its weather and climate monitoring system through improvement of its observing network and telecommunications, data processing and capacity building. Tanzania will need assistance to improve its meteorological services in response to the Climate Information and Prediction Services (CLIPS) initiative, while realizing that great strides of advances have been made in monitoring of the climate system, especially the capability to exchange that information in near-real-time using modern technologies. CLIPS is a direct follow-up of an initiative from the World Climate Applications and Services Programme (WCASP) under the auspices of the World Meteorological Organization (WMO) in response to the Climate Agenda. The climate Agenda seeks to integrate all aspects of international climate science activities including data collection and application, climate system research and studies of socio-economic impacts of climate variability and change.

In addition to the above observations TMA is constrained with the following problem, which requires assistance for the improvement of the TMA services in relation to systematic observation on climate change issues:

- Lack of equipment for climate observations;
- Lacking equipment for monitoring GHG and their related impacts on the atmosphere;
- Inadequate expertise to deal with systematic climate change observation;
- Lack of financial resources to undertake specific research and interpreting data so that can reach many end users in need of such information; and
- The need to enhance cooperation with international bodies particularly, on information exchange etc

7.2 RESEARCH

Basic research in climate related issues is being carried out at the University of Dar es Salaam, Sokoine University of Agriculture (SUA), Tanzania Forestry Research Institute (TAFORI), Mweka Wildlife College and Agricultural Research Institutes. The research is undertaken as part of normal scholarly activity and not necessarily for climate change. There is need to relate such research on subjects in energy, botany, atmospheric chemistry, physics, land degradation, forestry and others, to on-going work on climate change under the UNFCCC.

In 1996 the University of Dar es Salaam established a Professorial Chair in Energy Technology and Management. The establishment of Professorial Chairs is an innovative means of promoting quality and relevant research in areas beneficial to the University of Dar es Salaam, the government, the business community, and the nation at large. The main objective is to support high quality applied research on specific problems and to facilitate the transfer of ideas and technology between the University of Dar es Salaam and the local industry, the business community, government and the public through interdisciplinary and applied research.

In recognising the importance of climate, the Chair has already started sponsoring few students to undertake research for Masters' and *PhD* degrees on energy and climate change at the University of Dar es Salaam.

7.2.1 Research for National Communication

The Centre for Energy Environment Science and Technology (CEEST) has, since 1993, undertaken a number of climate related studies. CEEST has conducted studies on: the greenhouse gases emissions and sinks; technological option for the mitigation of GHG emissions; and the assessment of vulnerability and adaptation to climate change impacts. CEEST has also been involved in the undertaking of enabling activities towards the preparation of initial national communication to the United Nations Framework on Climate Change (UNFCCC) and in the preparation of a National Action Plan for Climate Change. In carrying out these activities the Centre has involved in-house experts and expertise from other institutions as part of a participatory approach in capacity building. Results of these studies have been discussed at various fora so as to create an understanding across the various sectors. The results of these studies have been published in the form of books.

A team of researchers who have participated in the previous climate change studies has been participating in the development of the Initial National Communication. In addition to these researchers, other experts have been co-opted for their input. The Division of Environment (DoE) has been the responsible authority, and CEEST the technical coordinator for this work. Figure 7.1 is a detailed institutional organization chart.

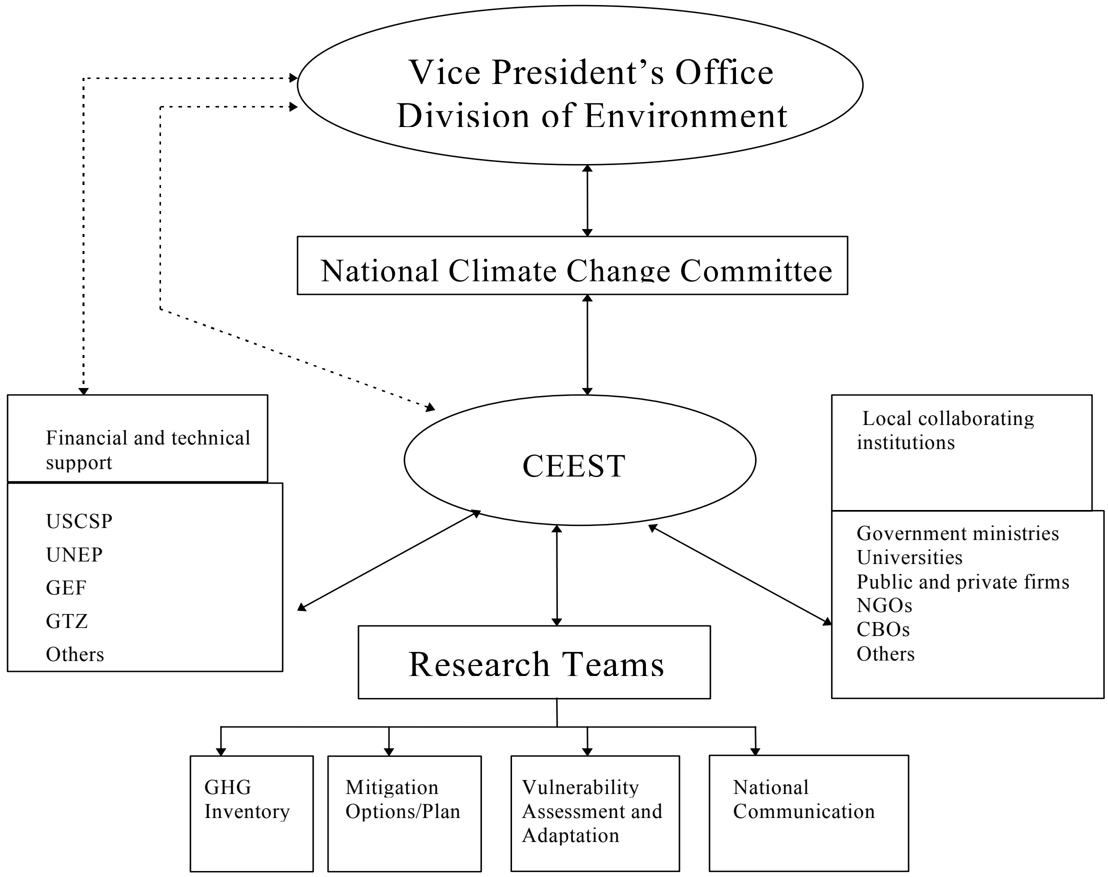

Figure 7.1: Organization of Climate Change Studies in Tanzania

(a) Objectives of Climate Change Studies

The climate change studies undertaken by the United Republic of Tanzania have the following objectives:

(i) To identify and quantify the anthropogenic sources of atmospheric emissions of greenhouse gases in Tanzania so as to further the scientific understanding of the relationship of GHG emissions to climate change;

(ii) To enhance the ability of various institutions in Tanzania to monitor, and report the inventories of GHG sources and sinks;

(iii) To identify the technologies associated with greenhouse gas emissions for various sectors and the appropriate best alternative technologies available in the country;

(iv) To investigate the various greenhouse gas abatement options, their reduction potential and costs; and recommend the best strategic (technological, and policy) options to mitigate emissions.

(v) To study the link between energy efficiency and the mitigation of GHG emissions and the cost involved and to recommend the possible policies for GHG mitigation targets or attaining stabilization particularly with regard to the requirement of the national energy policy;

(vi) To identify the areas of potential vulnerability and to make an assessment of the impact of climate change to such areas;

(vii) To analyse the feasibility, viability, and the costs of the proposed adaptation response options and recommend policy options.

Table 7.1: *Summary of Climate Change Studies Undertaken Under the Auspices of the Division of Environment*

	Study	Year	Financing Agency	Remarks
1	Inventory of GHG emissions	1993 to 1994	UNEP	The main GHG studied were CO_2, CH_4 and N_2O. Details of the result are reported in Chapter Two
2	Technological and other options for GHG Mitigation	1994 to 1995	The German Technical Cooperation (GTZ) Agency	The study involved the macro-economic analysis, energy pricing and mitigation cost analysis and a multiple criteria assessment. The proposed options are outlined in Chapter Three.
3	Assessment of Vulnerability and Adaptation to Climate Change	1994 to 1996	United States Country Studies Programme	The main sectors studied were: agriculture (crop production and livestock), water, coastal resources and forestry. Proposed adaptation response and measures are outlined in Chapter Six
4	Development of Climate Change National Action Plan	1996 - 1998	United State Country Studies Programme	Identification of the complimentary actions between climate change and sectoral policies.
5	Enabling Activities Towards preparation of the Initial National Communication to the UNFCCC	1997 - 1999	GEF/UNEP	The project updated the previous works of climate change studies, through capacity building

7.2.2 Project Concepts

The above-mentioned studies have been useful in creating baseline information and stimulating actions/measures that would address the impacts of global climate change to Tanzania. However, some of the proposed measures to mitigate emissions and the recommended adaptation strategies may not be implemented successfully due to the limited coverage of the areas of the existing studies. Hence there is a need to do further work in the relevant sectors. The proposed areas for further work include:

(A) ***Development of Baseline Information***

(i) Updating the 1994 and 1996 GHG inventory of sources and sinks so as to cover more sectors and improvement of data and information in accordance with revised methodologies;

(ii) Preparation of country specific emission factors;

(iii) Testing of modified General Circulation Models and analysing the resulting climate change scenarios and impacts for comparison with current predicted climate change results;

(iv) Incorporation of climate change scenarios in the hydrology and geology of the country;

(v) Undertaking of inter-basin water transfer studies in relation to the climate change scenarios developed.

(B) ***Coastal Resources***

(i) Undertaking Aerial Videotape-Assisted Vulnerability Analysis along the whole coastline of Tanzania and assessing the impacts due to sea level rises and storm surges;
(ii) Undertaking detailed studies of wave, climate and sediment transport in order to estimate erosion; and salinity and temperature variations necessary to predict sea level rise; and
(iii) Valuation of all the vulnerable structures along the entire coastline.

(C) ***Livestock and grassland***

(i) Studying and disseminating new technologies and management systems that improve on the indigenous knowledge of the agro-pastoralist and pastoralist;
(ii) Continuous assessment of climate change impact on grassland and livestock particularly in the country's marginal regions to ascertain ways to increase and sustain livestock production with minimum environmental degradation. Also to study livestock that are more tolerant to diseases and drought;
(iii) Research on agro-chemicals to counter diseases and pests that would probably increase with climate change;
(iv) Research on the development of pasture and tree fodder crops to enhance the sustainability of livestock and dairy cattle if climate changes occur;
(v) Research on the processing of livestock products to increase their shelf life.

(D) ***Crop Production***

(i) Identification and assessment of impacts to agricultural systems and an analysis of the adaptation responses;
(ii) Detailed assessment of vulnerability and adaptation responses to important crops other than maize, coffee and cotton;
(iii) Research on agro-chemicals to counter diseases and pests that would probably increase with climate change;
(iv) Evaluation of adaptation responses in relation to crop yields and markets;
(v) Development and broad application of integrated agricultural modelling efforts and approaches particularly those that are applicable at regional scale including increased attention to the validation, testing and comparison of alternative approaches;
(vi) Research on the development of drought-resistant cultivars;
(vii) Development and the broad application of water management techniques in irrigation;
(viii) Improvement of the models and analytical methods used to assess the impacts of climate change to maize, coffee and cotton taking into account the effects of changes in management as the climate changes.

(E) ***Forestry***

(i) Improvement of the models and analytical methods used to assess the impacts of climate change on forest in order to include more parameters;
(ii) Continued research on the vulnerability of climate change to forest;
(iii) Conducting research to identify plant species that are adaptable to climate change; and
(iv) Development of the improved use of forests and forests products.

(F) ***Biodiversity and Wildlife***

(i) Further research on the impacts of climate change on the terrestrial biodiversity and habitat;
(ii) Study of the impact of climate change on endangered and endemic species to see how these will cope with global climate change.

(G) ***Energy***

(i) Research into the environmental impacts of energy-related developments;
(ii) Embarking on industrial energy audits and ways of improving energy efficiency;
(iii) The promotion of appropriate and affordable renewable energy technologies;
(iv) Implementation of a national programme to promote renewable energy technologies and energy conservation in Tanzania. (Details of the programme are shown in Box 7.1)

(H) ***Malaria Disease***

(i) Detailed assessment of the climate change impacts on malaria and the adaptation responses;
(ii) Research on feasible and viable chemical and biological control options to counteract malaria as climate change occurs; and
(iii) Development and broad application of integrated malaria control.

Box 7.1: A National Programme to Promote Renewable Energy Technologies and Energy Conservation in Tanzania

A five-year National Programme to promote renewable energy development in the country was approved in April 1998. The programme is a guide for the development of renewable energy technologies and energy conservation in Tanzania. Different stakeholders will be involved in implementing the relevant parts of the programme in an effort to guarantee a sustainable supply of energy to the majority of Tanzanians. The programme identifies priority areas, mechanisms for implementation, assesses the current energy situation, analyses the positive indicators, constraints and challenges. The national programme consists of six components:
(a) Awareness Creation
(b) Energy Policy and Planning.
(c) The Promotion of Renewable Energy Resource Utilization.
(d) The Rational Use of Energy/Energy Conservation.
(e) Human Resource Development.
(f) Institutional Framework Development.

The programme will promote the development, demonstration and application of renewable energy technologies including geothermal and wind energy, biogas, efficient charcoal and wood fuel stoves and solar energy. An assessment of the human resource needs and technical capability to facilitate the design and servicing of technologies will be done. Community level solar demonstration projects, which aim at involving the private sector in the demonstration and dissemination of renewable energy technologies, will be promoted for sustainability. Research also will be undertaken to assess the financial and market strategies to encourage the faster adoption of these technologies.

8: THE NATIONAL IMPLEMENTATION STRATEGY

8.1 INSTITUTIONAL FRAMEWORK

The institutional framework for climate change in Tanzania should take into account the need for an economy-wide holistic approach to mitigation and adaptation. Article 4 paragraph one, sub-paragraph (c) of the UNFCCC states: "…Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including energy, transport, industry, agriculture, forestry and waste management sectors". The exploitation of sectoral synergies is therefore an important element. In Tanzania climate change studies have been organized in such a way that all the relevant sectors are involved. The institutions that are the main players in this respect include the Division of Environment, the Tanzania Meteorological Agency, the Department of Energy, Universities, and non-governmental institutions, and the National Climate Change Steering Committee (NCCSC) under the chairmanship of the Division of Environment. CEEST provides the secretariat for the steering committee.

8.1.1 The Division of Environment

The Division of Environment, under the office of the Vice President, is a focal point for all matters related to environment. The Division of Environment has also been a link between the government of the United Republic of Tanzania and the United Nations Environment Programme (UNEP) on the development of the Initial National Communication. The Division of Environment is the national focal point for the UNFCCC.

8.1.2 The Tanzania Meteorological Agency

The responsibility for providing meteorological data to the country's planners and other users is officially vested in the Tanzania Meteorological Agency (TMA), which was established in 1999 under an Act of Parliament. The TMA also issues climate information and predictions. These predictions are complemented by similar products from the Drought Monitoring Centres (DMCs) in Nairobi Kenya and in Harare Zimbabwe and by the African Centre for Meteorological Applications for Development (ACMAD) in Niamey, Niger as well as the European Centre For Medium Range Weather Forecasting (ECMWF).

However, the services rendered by the TMA are limited by lack of adequate and reliable meteorological data and information, modern data collection and processing systems and data dissemination facilities, expert know-how and skilled and developed manpower. There are at the moment 23 synoptic stations, and 13 agro-meteorological stations. Two of the 23 synoptic stations are agro-synoptic and are among the 13 agro-meteorological stations. There are also 100 climatological stations and 1400 rainfall stations. Of the 23 synoptic stations, 4 have upper air observatories. In some of these stations, rainwater is collected for precipitation chemistry studies and atmospheric pollution monitoring.

8.1.3 The Centre for Energy, Environment, Science, and Technology (CEEST*)*

Since its establishment in 1992, CEEST has been able to develop the expertise and facilities necessary for research and coordination of climate change work. It has an extensive network of researchers and associates. CEEST has undertaken a number of climate change studies in Tanzania. CEEST has been responsible for the compilation of the national communication. Furthermore, CEEST has provided technical and administrative backstopping to the National Climate Change Committee and the climate change study teams. The study teams meet regularly to review progress and exchange ideas and information in order to ensure quality and timely outputs of the studies.

8.1.4 The National Climate Change Committee (NCCC)

The National Climate Change Committee comprises members from government ministries and institutions, nongovernmental organizations (NGOs), and academic and research institutions. The main function of the committee is to advise the division of environment on climate change-related issues and options in the country. The committee receives periodic reports for review. It gives advice on the study implementation process and provides guidance to researchers. The NCCC is made up of the following twelve members:

- Director for Environment (NCCC Chairman);
- Director General of Meteorology (NCCC Co-Chairman);
- Director General of National Environment Management Council;
- Commissioner for Energy and Petroleum Affairs;
- Representative from the Planning Commission;
- Representative from the Ministry of Foreign Affairs and International Cooperation;
- Representative from the Attorney General's Chambers;
- Director for Fisheries
- Director for Forestry;
- Commissioner for Agriculture;
- Representative from the University of Dar es Salaam;
- Tanzania Chamber of Commerce Industry and Agriculture;
- Chairman/Director of CEEST.

CEEST provides the secretariat for the NCCC.

8.2 CLIMATE CHANGE STUDIES

In order to ensure that different aspects of climate change are included in the climate change studies as well as the development of the initial national communication, a number of experts from different sectors have been included in the study teams. Individual members of the study teams have had the following responsibilities and sectoral foci, among others:

- Overall guidance on both technical and administrative aspects of the study (Team Leader);
- Technical coordination of the study and responsibility for work on the environmental aspects (Assistant to the Team Leader);
- Management of project finances and guidance on preparation of the energy sector (Financial Coordinator);

Sectoral aspects of relevance have included:

- The energy and transport sectors;
- The agricultural sector;
- The water resources sector;
- The livestock and rangeland/grassland resources sector;
- The wildlife and biodiversity resources sector;
- The coastal resources sector;
- The forestry sector; and
- The economic and industrial sectors.

Technical inputs for the climate change studies including those for this communication have been obtained from various governmental institutions and agencies. These include the Planning Commission, Ministry of Finance, Central Statistics Bureau, the University of Dar es Salaam and other agencies involved in the national planning process.

8.3 EDUCATION, TRAINING AND PUBLIC AWARENESS

Articles 5 and 6 of the Convention emphasize the need to sustain knowledge of the climate system through research and systematic observation as well as education, training and public awareness. This implies universal participation in climate change issues. In this regard players include governments, private and public institutions, the general public and individuals. This calls for awareness creation as well as knowledge of fundamental relationships of anthropogenic activities and climate change. Universal participation will also require attainment of a critical mass of expertise in climate change.

8.3.1 Education and Training

The following aspects would need to be considered in a training programme on climate change in Tanzania:

(a) ***Baseline Data and Information***

(i) The development of greenhouse gases' inventory.
(ii) The development of country specific emission factors.
(iii) The use of country/regional specific information to develop numerical models (General Circulation Models - GCMs).
(iv) The application of GCMs in assessing vulnerability to climate change.
(v) Identifying technologies that emit greenhouse gases and assessment of technological and policy options for mitigating greenhouse gases emission.
(vi) Undertaking a socio-economic analysis of the appropriate technological and policy mitigation options.
(vii) An assessment of the vulnerability and adaptation responses to the impact of climate change.
(viii) Socio-economic analysis of the adaptation responses that are feasible.

(b) ***Energy***

(i) Energy auditing; and development and assessment of efficiency raising options.
(ii) Design of energy conservation systems.

(iii) Development of renewable energy sources and prioritisation of feasible choices for future development.
(iv) Assessment of various policy options in developing renewable sources, their economic implications and best scenarios for development.
(v) Demonstration of solar energy in rural areas.

(c) *Water Resources*
(i) Water use auditing and the better management of the water demand.
(ii) Water conservation measures at the source and at the end use.
(iii) Waste water re-use and recycling.
(iv) Water supply management technologies.
(v) An assessment of effects of climate change on the water resources.

(d) *Crop Production*
(i) Water and land management to reduce the emission of greenhouse gases and increase efficiency in the utilization of water.
(ii) An assessment of the effects of climate change on agriculture.
(iii) An assessment of feasible technological, policy and economic options.
(iv) Linking agricultural management to seasonal climate prediction.
(v) Food preservation techniques and their demonstration in rural areas.
(vi) Pest and disease control.
(vii) The demonstration of drought-resistant crop cultivars.

(e) *Livestock*
(i) Effects of climate change on livestock and grasslands.
(ii) The development and dissemination of improved livestock technologies.
(iii) The demonstration of livestock products' processing.
(iv) The development of new management systems and the making of demonstrations for their adoption.
(v) Pest and disease control.

(f) *Forestry and Biodiversity*
(i) Effects of climate change to biodiversity.
(ii) Better forest management practices.
(iii) Development of country specific methodologies for assessing the impacts of climate change
(iv) The development of plant species adaptable to climate change and the demonstration of feasible alternative uses of forest and forest products.

8.3.2 Public Awareness

It would be easier for people to implement climate change aspects in policies, plans and programmes if the general public were aware of its linkages with their daily lives, the necessity to take up action and what to do. People need to know that the climatic variations they had experienced are linked to the environmental degradation arising from human development activities. It is important for the people to be in a position to differentiate between the normal climatic variations they already know and the anticipated greenhouse-induced climatic change so that they can experience the extent of the damage/problems that could arise when global climate change occurs. Such an understanding of issues will help the implementation of adaptation responses in a manner most convenient and affordable to them. This can be done through the systematic upgrading of the indigenous techniques to accommodate the recent scientific and technological advancement caused by climate change.

The general public awareness of the climate change phenomena, impacts and responses is still very low. There is visible climate variability that goes unnoticed as people do not differentiate between the normal and the abnormal, that is, the induced climate variability caused by climate change. To many people climate change does not seem to be a priority issue. This kind of perception is caused by lack of awareness on how climate variability and change impinges on their socio-economic development. It is therefore very crucial, for Tanzania, to initiate a comprehensive awareness programme targeting the different user groups of the environment. These groups include agro-pastoralists, pastoralists, industrialists, government agencies, private/public organizations, professional associations and communities.

A public awareness programme in Tanzania would need to encompass many important subjects relevant to the specific groups. The programme could cover, among others, the relevance of climate variability and change; the causes of climate change; the greenhouse gases mitigation options; the vulnerability of socio-economic sectors; and the extent, feasibility and viability of adaptation response options that have been tested and examined in the country and elsewhere. Stakeholders would need to be involved from the designing stage to ensure it captures all the relevant issues that need to be incorporated into this programme. Different methodologies will be applied including TV and radio programmes, newsletters and pamphlets. The programme will be run in English and Kiswahili in order to ensure that a large proportion of the population becomes aware of climate change issues.

8.4 FINANCIAL, AND CAPACITY CONSTRAINTS AND NEEDS

The main challenge is the need to balance accelerated economic growth with the more efficient management of the environment and use of natural resources to ensure sustainability and address the issues of climate change. Indeed, the need for substantial concessional financial and technical assistance is imperative taking account the magnitude of the structural constraints faced by the Tanzania’s economy. Assistance is required to build up the capacity in assessing the current situation and internalising the processes of overcoming the constraints.

Substantial resources and capacity development are required for the country in order to be in a position to contribute actively towards economic and social development and poverty alleviation and the implementation of the United Nations Framework Convention on Climate Change. Specifically, financial requirements are needed for training, research, sensitisation and technological diffusion and development. The following are areas of interest in this aspect:

8.4.1 Strengthening of Centres of Excellence and Relevant Government Institutions

This could be done through:

- Provision of hardware, software;
- Establishment at these institutions climate related libraries and data banks making these institutions depositaries of information and data on issues related to climate change, through the use of information technology;

- Development of capacity for effective implementation of the Convention and the Kyoto Protocol

8.4.2 Human Resources Development

This could be implemented through:

- Facilitation of short and medium term training in climate related subjects, including negotiating;
- Skills to the relevant government ministries, non-governmental organisations and centres of excellence, especially those responsible for energy and environment;
- Provision of scholarships for research and studies on climate change as well as development of relevant skills;
- Facilitation of attendance to national, regional and international seminars and workshops by these Centres; and
- Undertaking of scientific work and other studies to support national implementation activities

8.5 TECHNOLOGICAL CONSTRAINTS AND NEEDS

Currently, science and technology is at a low level both in terms of its development and utilization in all major sectors and activities in society. The requirements for technological development include among others

- Strengthening of technological management capacities;
- Establishment and strengthening of linkages and working relationships between the science and technology community and the economic and social policy makers;
- Establishment and strengthening of linkages between R&D institutions, academia and the productive sectors' activities;
- Identification of reliable financing mechanisms for technological innovation and investment in technology, especially the new and emerging kind.

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There is a need to strengthen the national capacity to manage technological change. The main challenge is to enlarge the country's human resource capacity.

8.6 NATIONAL CLIMATE CHANGE ACTION PLAN

Tanzania will implement a National Action Plan on Climate Change (NAP). The plan is integrated with the other national development plans and programmes. The Division of Environment in the Vice President's Office will ensure that the plan is integrated into other programmes by channelling it through normal official planning procedures. The plan will also be publicized through media workshops and seminars for various stakeholders, including the business community, so that a larger community in the country understands it.

The roles of various players including the private sector is highlighted in the plan including some policies and measures leading to mitigation of GHG emissions as well as barriers to its implementation.

8.6.1 International Cooperation and Capacity Building

Tanzania's climate change study team has attended a number of training workshops organized by the US Country Studies Program (USCSP), United Nations Environmental Programme (UNEP), and other international institutions geared towards assisting participating countries in the acquisition of relevant methodologies for the development of national climate change studies and national action plans.

Additional technical assistance will be needed in some priority areas to facilitate the implementation and updating of the climate change action plan, including identifying and training of experts in appropriate methodologies for analysing the activities under the plan as well as use of proper modelling techniques. Developing a capacity in and the use of information technology will be crucial in many regards. The following assistance will be needed:

i) *Training on key steps in plan development and technology assessment*. This assistance will be required at the review stage of the plan. Training on sector-specific needs will be emphasized as part of capacity building to ensure a stable base of climate change expertise in the country.

ii) *Provision of appropriate technical literature on plans and technology assessments*. Since the National Action Plan preparation is a continuous process, availability of relevant literature is essential for the individuals involved in the implementation as well as updating of the plan. Potentially useful literatures include those that give guidance on the various approaches and strategies taken in other countries.

iii) *Backstopping from international experts*. Assistance is needed in the planning process, design and interpretation of analyses for alternative policies and programs, the identification of capacity needs, and technology assessment.

iv) *Exchange of information with other countries preparing national plans*. This could be accomplished through participating in international workshops on national plans, distributing copies of plans prepared by other countries, and supporting the exchange of experts between countries within our region. It is suggested that funding should be provided to enable local experts to participate in workshops on issues related to NAP development, including workshops arranged for countries participating in the NAP preparation process.

v) *Provision of analytical tools*. Computer based tools are needed for evaluating alternative policies, programs, and technologies and should include reference manuals for these tools. Assistance will be required to facilitate the acquisition of different models that will be applied to analysis at various stages of the plan. The models would include macroeconomic models, multi-criteria decision models, etc. It is necessary at this stage to facilitate unbundling of the models so that local researchers can update them and whenever necessary change them to suit local conditions.

8.6.2 Future Outlook

The climate change action plan will be updated regularly based on recommendations from a body that will be reviewing the progress of the implementation process. Updating the implementation of the plan will depend on the availability of funds. An incentive package would be proposed to encourage the various stakeholders to implement the plan.

Implementation of the plan will require capacity building in terms of training and institutional strengthening. Detailed national capacity requirements for the National Action Plan implementation and technology transfer and technology cooperation will be undertaken and be incorporated during the revision of the plan.

Tanzania is committed to signing and ratifying the Kyoto Protocol to the UNFCCC.

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APPENDIX I
Standard IPCC Tabulation for GHG Inventory

STANDARD DATA TABLE 1 Energy: 1A Fuel Combustion Activities - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSION ESTIMATES					
	A	B					
Sector Specific Data (unit) by fuel	Consumption (PJ)	Quantities Emitted (Gg of Full Mass of Pollutant)					
1A Energy Transformation Sheet 4		CO_2	CH_4	N_2O	NOx	CO	NMVOC
1A1a Electricity and Heat Production							
i Industrial Diesel Oil	1.0065	73.779	0.010	0.0019124	0.9159	0.634116	0.1308
ii Lubricants	0.0001	0.007	NA	0.0000002	0.0002	0.000004	NA
Total	***1.007***	***73.786***	***0.010***	***0.002***	***0.916***	***0.634***	***0.131***
Sheet 5							
1A1b Petroleum Refining							
i Fuel Oil Boilers	0.153	10.68	0.00044	0.0000092	0.0247	0.0023	NA
ii Fuel Oil Furnaces	0.538	37.47	0.00027	0.0000323	0.0274	0.0070	NA
iii LPG Furnaces	0.010	0.65	0.00001	0.0000001	0.0005	0.0001	NA
iv Fuel Gas Furnaces	0.750	46.83	0.00083	0.0000075	0.0375	0.0143	NA
Total	***1.451***	***95.635***	***0.00155***	***0.00005***	***0.090***	***0.0236***	***NA***
Sheet 10							
1A4 Small Combustion (fossil fuels)							
1A4Ahh/Commercial/Institutional	16.075	1139.44	0.076	NA	0.815	0.205	NE
1A4b Households (fossil fuels)	NA	NA	NA	NA	NA	NA	NA
1A4c Agriculture/Forestry	0.177	12.97	0.002	0.0004	0.266	0.106	0.041
Total	***16.252***	***1152.412***	***0.078***	***0.0004***	***1.081***	***0.311***	***0.041***
Sheet 11							
1A4a Commercial/Institutional/Households							
(i) Kerosene Stoves and Lanterns	14.906	1065.779	0.075	NA	0.760	0.194	NA
(ii) LPG stoves	1.169	73.659	0.001	NA	0.055	0.012	NA
Total	***16.075***	***1139.438***	***0.076***	***NA***	***0.815***	***0.205***	***NA***
Sheet 13							
1A4c Agriculture/Forestry							
(i) Diesel Farm Equipment	0.177	12.974	0.0019	0.0004	0.2655	0.1062	0.0407
Total	***0.177***	***12.974***	***0.0019***	***0.0004***	***0.2655***	***0.1062***	***0.0407***
Sheet 15							
1A5 Other Modes							
1A5a Construction Equipment	1.415	103.72	0.00566	0.0028	1.70	0.54	0.1274
Sheet 16 - Traditional Biomass Burned for Energy							
Fuelwood	27765	39856.66	173.92	1.20	33.57	1014.53	NE
Agricultural Wastes	5597	7404.46	13.46	0.33	9.36	188.48	NE
Cattle Dung	97	108.83	0.67	0.01	0.18	2.77	NE
Charcoal (Consumption)	772	2167.16	1.10	0.07	2.35	82.75	NE
Charcoal (Production)	7718	10272.02	235.32	0.31	8.65	261.47	NE
	Total	***59809.13***	***424.48***	***1.91***	***54.11***	***1550.00***	***NE***

STANDARD DATA TABLE 1 Energy: 1A Fuel Combustion Activities: Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSION ESTIMATES					
	A	B					
Sector Specific Data (unit) by fuel	Consumption (PJ)	Quantities Emitted (Gg of Full Mass of Pollutant)					
Sheet 6 1A1c Solid Fuel Transformation		CO_2	CH_4	N_2O	NOx	CO	NMVOC
a. Food, Beverages and Tobacco							
i. Wood fuel Furnaces	12.4575	NA	0.186862	NA	1.4326	18.7361	
ii. Wood fuel Boilers	0.1293	NA	0.001940	NA	0.0149	0.1945	
iii. Bagasse Boilers	3.8966	NA	NA	NA	0.3429	6.6475	
b. Textile, Leather and Sisal							
i. Sub-bituminous Coal Boilers	0.0015	0.142	0.000004	0.0000002	0.0005	0.0001	
c. Metal and Engineering							
i Coke Furnace	0.0005	0.045	0.000001	0.0000001	0.0001	0.0002	
d. Wood, Wood Products & Printing							
i Wood fuel Boilers	0.3388	NA	0.005082	NA	0.0390	0.5096	
ii Sub-bituminous Coal Boilers	0.3715	35.296	0.000892	0.0000520	0.1222	0.0346	
e. Non-metal and Mineral Products							
i. Sub-bituminous Coal Boilers	0.1869	17.753	0.000448	0.0000262	0.0615	0.0174	
Total	***17.383***	***53.236***	***0.1952***	***0.000078***	***2.0137***	***26.140***	

STANDARD DATA TABLE 1
Energy: 1A Fuel Combustion Activities - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSION ESTIMATES					
	A	B					
Sector Specific Data (unit) by fuel	Consumption (PJ)	Quantities Emitted (Gg of Full Mass of Pollutant)					
Sheet 7 1A2 Industry (ISIC)		CO_2	CH_4	N_2O	NOx	CO	NMVOC
a. Food, Beverages and Tobacco							
i. Fuel Oil Boilers	1.436	100.06	0.004163	0.00008613	0.2311	0.02153	NA
ii. LPG Boilers	0.006	0.35	0.000008	0.00000006	0.0004	0.00009	NA
iii. Industrial Diesel Oil Boilers	0.033	2.36	0.000096	0.00000199	0.0053	0.00050	NA
b. Textiles, Leather and Sisal							
i. Fuel Oil Boilers	0.571	39.82	0.001657	0.00003427	0.0920	0.00857	NA
ii. Industrial Diesel Oil Boiler	0.008	0.56	0.000023	0.00000047	0.0013	0.00012	NA
iii. Kerosene Kilns	0.001	0.04	0.000001	0.00000004	0.0003	0.00005	NA
c. Metal and Engineering							
i. Fuel Oil Furnaces	0.048	3.33	0.000139	0.00000287	0.0024	0.00072	NA
ii. Industrial Diesel Oil Boilers	0.012	0.82	0.000034	0.00000069	0.0019	0.00015	NA
iii. Industrial Diesel Oil Furnaces	0.038	2.71	0.000019	0.00000229	0.0061	0.00050	NA
d. Wood, Wood Products &Printing							
i. Fuel Oil Boilers	0.209	14.57	0.000606	0.00001254	0.0337	0.00314	NA
e. Non-metal and Mineral Products							
i. Fuel Oil Kilns	2.863	199.56	0.002863	0.00017179	1.5089	0.22619	NA
ii. Fuel Oil Furnaces	0.653	45.52	0.000327	0.00003918	0.0333	0.00849	NA
iii. LPG Furnaces	0.011	0.67	0.000012	0.00000011	0.0005	0.00011	NA
Total	***5.887***	***410.36***	***0.010***	***0.0004***	***1.917***	***0.270***	***NA***

Sheet 14							
1A3 Transportation							
1A3 (a,c,d) Non-road Transport							
1A3a i Gasoline Piston Aircraft	0.681	47.19	0.04086	0.0006	0.05	16.34	0.3677
1A3a ii Jet and Turbo Aircraft	0.627	44.83	0.00125	0.0013	0.18	0.08	0.0113
Sub-total	***1.308***	***92.02***	***0.04211***	***0.0019***	***0.24***	***16.42***	***0.3790***
1A3c Diesel Locomotive Engines	1.002	73.45	0.00601	0.0020	1.80	0.61	0.1303
Sub-total	***1.002***	***73.45***	***0.00601***	***0.0020***	***1.80***	***0.61***	***0.1303***
1A3d i Boats and Schooners	0.216	15.83	0.00108	0.0004	0.35	0.11	0.0238
1A3d ii Shipping activities	0.165	12.09	0.00002	0.0003	0.35	0.01	0.0000
Sub-total	***0.381***	***27.93***	***0.00110***	***0.0008***	***0.69***	***0.12***	***0.0238***
Grand total Non Road Transport	***2.691***	***193.3977***	***0.0492225***	***0.0046329***	***2.73201***	***17.14605***	***0.5330625***
(Sheet 9)							
1A3b Road Transportation							
i Gasoline Automobiles	1.842	127.65	0.058	0.0017	0.718	13.502	2.0999
ii Gasoline Light-duty trucks	1.706	118.23	0.097	0.0015	0.699	11.754	2.2519
iii Gasoline Heavy-duty trucks	0.395	27.37	0.008	0.0002	0.138	3.500	0.4424
iv Gasoline Motorcycle	0.380	26.33	0.049	0.0003	0.027	3.496	0.9500
v Diesel Automobiles	1.602	117.43	0.002	0.0030	0.224	0.240	0.1169
vi Diesel Light-duty trucks	3.872	283.82	0.004	0.0074	0.658	0.736	0.3872
vii Diesel Heavy-duty trucks	1.543	113.10	0.015	0.0029	1.558	0.787	0.2777
Total	***11.340***	***813.93***	***0.234***	***0.017***	***4.024***	***34.015***	***6.526***

STANDARD DATA TABLE 1
Energy: 1B *Fugitive Emissions From Fuels (Coal Mining and Carbon dioxide Exploitation)*

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSION ESTIMATES	
	A		B	
Sector Specific Data (unit)	Production and Importation		Emission Estimates	
	(Million tonnes)		(Gg)	
	Coal	CO_2	CH_4	CO_2
1B Fugitive Emissions				
1B1 Solid Fuels				
1B1a Coal Mining				
1B1ai Underground Mines				
Underground activities	0.0603		0.751	
Post-mining activities	0.0823		0.069	
1B1b Gaseous Exploitation				
1B1bi Carbon dioxide Exploitation		0.00126		1.260
Total	***0.0823***	***0.00126***	***0.820***	***1.260***

STANDARD DATA TABLE 2
Industrial Processes

SOURCE AND SINK CATEGORIES Sector Specific data (Units)	ACTIVITY DATA A Production Quantity (kt)	EMISSION ESTIMATES B Full Mass of Pollutant (Gg)					
		CO	CO_2	CH_4	N_2O	NOx	NMVOC
E Non-metallic Mineral Products							
Cement	644.14	NE	343.666	NE	NA	NA	NE
F Other Products (ISIC)							
Pulp and Paper	7.38	NE	5.787	NE	NA	NA	NE
	Total	***NE***	***349.453***	***NE***	***NA***	***NA***	***NE***

STANDARD DATA TABLE 4
Agriculture: 4A&B *Enteric Fermentation and Manure Management*

SOURCES AND SINKS CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES		AGGREGATE EMISSION FACTOR	
	A	B		C	
	Number of Animals	Enteric Fermentation	Manure Management	Enteric Fermentation	Manure Management
	(thousands)	(Gg CH_4)		(kg CH_4 per head per year) C=(B/A)x1000	
1 Cattle					
a Indigenous	11510.22	562.48	4.542	48.87	0.39
b Beef	115.80	7.01	0.055	60.53	0.47
c Dairy	209.76	9.96	0.132	47.50	0.63
d Oxen	900.00	85.82	0.355	95.36	0.39
2 Buffalo					
3 Sheep	5551.40	116.90	0.963	21.06	0.17
4 Goats	8533.70	88.32	1.480	10.35	0.17
5 Camels and Llamas					
6 Horses					
7 Mules/Asses	250.00	2.50	0.147		0.59
8 Swine	275.00	0.28	0.008		0.03
9 Poultry	21617.50		0.375		0.02
10 Other					
Total		*873.271*	*8.057*		

STANDARD DATA TABLE 4
Agriculture: 4C Rice Cultivation - Flooded Rice Fields

SOURCE AND SINK CATEGORIES		ACTIVITY DATA		EMISSION ESTIMATES
	Sector Specific Data (units)	A Area Calculated in Megahectares	B Megahectares-Days Cultivation	C Methane
		(Mha)	(Mha-Days)	(Gg CH_4)
1	Flooded or irrigated	0.04	5.03	20.967
2	Intermittently lowland rain-fed	0.27	25.46	63.789
3	Other			
	Total	***0.31***	***30.49***	***84.756***

STANDARD DATA TABLE 4
Agriculture: 4D Agricultural Soils - Nitrogenous Fertilizers

SOURCE AND SINK CATEGORIES	ACTIVITY DATA			EMISSIONS			REMOVALS
	A	B	C	D	E	F	G
Fertiliser Type	Amount of Nitrogen Applied in Fertiliser and Manure	Area Cultivated	Amount of Biological Fixation of Nitrogen	Emissions of N_2O, CO_2, CH_4 at low emission rate			Removals of CO_2
	(t N)	(ha)	(tN)	(Gg)			(Gg CO_2)
				D	E	F	
				N_2O	CO_2	CH_4	
Ammonia Aqua	1625			0.026			
Ammonium Nitrate	510			0.008			
Ammonium Sulphate	6107			0.096			
Urea	17227			0.271			
NPK 6:20:18	678			0.011			
NPK 25:5:5	993			0.016			
NPK 20:10:10	654			0.010			
Calcium Ammonium Nitrate (CAN)	8308			0.131			
Total				*0.567*			

STANDARD DATA TABLE 4
Agriculture: 4E   Field Burning of Agricultural Residues

SOURCE AND SINK	ACTIVITY DATA		EMISSIONS ESTIMATES				
	A	B	C				
Crop Type	Amount Burning Of Crop Residues	Carbon Fraction	Full Mass of Pollutant				
	(Gg dm)	(t / t dm)	(Gg)				
			CH_4	N_2O	NOx	CO	C
1. Cereal (Rice husks)	107.258	0.30	0.429	0.004	0.149	10.51	32.18
2. Pulse							
3. Tuber and roots							
4. Sugar cane (leaves)	36.564	0.41	2.199	0.003	0.109	1.75	14.99
5. Other (Cotton residuals)	9534.953	0.36	320.374	0.566	20.470	1041.22	3432.58
Total			***323.002***	***0.573***	***20.729***	***1053.477***	

STANDARD DATA TABLE 4
Agriculture: 4F (Sheet 1) *Un-prescribed Burning of Savannas - Carbon dioxide Released*

SOURCE AND SINK CATEGORIES		ACTIVITY DATA										EMISSIONS ESTIMATES	
		A	B	C	D	E		F		G		H	
Sector Specific Data		Estimated Area under Savanna	Fraction Annually Burned	Aboveground Biomass Density	Fraction Actually Burned	Fraction of Aboveground Biomass		Combustion Efficiency		Fraction of in Carbon Biomass		Total Carbon Released	
Land Type		(kha)		(t dm/ha)								(Gg) H=AxBxCxDxExFxG	
						Living	Dead	Living	Dead	Living	Dead	Living	Dead
Savanna	Humid	10400	0.32	6.60	0.85	0.85	0.15	0.80	0.99	0.40	0.45	5078.3	1247.6
	Semi Arid	5600	0.32	4.50	0.90	0.65	0.35	0.80	0.99	0.40	0.45	1509.6	1131.6
	Total	***16000***											***8967.2***

STANDARD DATA TABLE 4
Agriculture: 4F (Sheet 2) *Un-prescribed Burning of Savannas - Non-Carbondioxide Greenhouse Gas Emissions*

SOURCE AND SINK	ACTIVITY DATA				EMISSIONS ESTIMATES			
	A		B		C			
Sector Specific Data (units) Land Type	Total carbon released (kt C)		Equivalent nitrogen released (kt N)		Full Mass of Pollutant (Gg)			
	Living	Dead	Living	Dead	CH_4	CO	N_2O	NOx
Humid Savanna	5078.262	1247.628	30.470	7.486	33.738	885.625	0.418	15.090
Semi-arid Savanna	1509.581	1131.641	9.057	6.790	14.087	369.771	0.174	6.300
Total	***6587.843***	***2379.269***	***39.527***	***14.276***	***47.825***	***1255.396***	***0.592***	***21.390***

S TANDARD DATA TABLE 5

Land Use Change & Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stocks - Annual Growth Increment

SOURCE AND SINK CATEGORIES			ACTIVITY DATA	UPTAKE ESTIMATES
			A	B
Sector Specific Data (units) Land Type			Area of Forest/Biomass Stocks (kha)	Total Carbon Uptake Increment (Gg C)
Tropical Forests	Plantation Forests	Mixed Softwoods	70.00	346.500
		Mixed Hardwoods	10.00	22.050
	Natural Forests	Miombo woodlands	55.20	99.360
	Others	Village Woodlot	12.00	27.000
Non-forest trees planting programmes in urban and rural areas			Number of Trees (thousands)	Annual Carbon Uptake (Gg)
Urban and Rural Tree Planting Programmes			12.00	0.026
Total				***494.936***

STANDARD DATA TABLE 5

Land Use Change & Forestry: 5A (Sheet 2) Changes in Forest and Other Woody Biomass Stocks - Annual Biomass Harvest

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	CARBON EMISSION ESTIMATES
Sector Specific Data (units)	A Amount of Biomass Removed (kt dm)	B Carbon emission estimates (Gg C)
Total biomass removed (commercial harvest)	265.478	
Traditional biofuel consumption (HH/commercial/informal)	35483.000	
Other wood use (mainly poles)	5.558	
Surplus (from off-site burning) aboveground biomass	-1852.510	
Net biomass consumption	***33901.525***	***15255.686***

STANDARD DATA TABLE 5

Land Use Change & Forestry: 5A (Sheet 3) Changes in Forest and Other Woody Biomass Stocks - Carbon dioxide Emissions or Removals

SOURCE AND SINK CATEGORIES	EMISSIONS/UPTAKE	EMISSIONS/REMOVALS
Sector Specific Data (units)	A Carbon (Gg)	B Carbon dioxide (Gg)
		B=A x(44/12)
Total annual growth increment of woody biomass	-494.936	
Total annual harvest and biofuel consumption	15255.686	
Net carbon dioxide emissions or removals	***14760.750***	***54122.750***

STANDARD DATA TABLE 5

Land Use Change & Forestry: 5B *(Sheet 1) Forest conversion for permanent agriculture- Carbon dioxide release from burning aboveground biomass*

SOURCE AND SINK CATEGORIES				ACTIVITY DATA				EMISSION ESTIMATES	
Sector Specific Data (units)				A Area Converted Annually	B Annual Loss of Biomass	C Quantity of Biomass Burned (On-Site and Off-Site)		D Quantity of Carbon Released	
Land Type				(kha)	(kt dm)	(kt dm)		(kt C)	
						On-Site	Off-Site	On-Site	Off-Site
Tropical Forests	Closed Forests	Broadleaf Forests	Logged	5.19	212.79	42.56	159.59	17.24	
			Unproductive	0.71	118.57	23.71	88.93	9.60	
			Sub-total	***5.90***	***331.36***	***66.27***	***248.52***	***26.84***	
	Open Forests	Miombo Woodlands	Productive	46.41	1021.02	204.20	765.77	82.70	
			Unproductive	13.09	26.18	5.24	19.64	2.12	
			Sub-total	***59.50***	***1047.20***	***209.44***	***785.40***	***84.82***	
	Open Woodlands	Bushlands And Thickets	Productive	18.10	506.80	101.36	380.10	41.05	
			Unproductive	5.1	30.60	6.12	22.95	2.48	
			Sub-total	***23.20***	***537.40***	***107.48***	***403.05***	***43.53***	
Total on-site carbon released				***88.60***	***1915.96***	***383.19***	***1436.97***	***155.19***	

STANDARD DATA TABLE 5

Land Use Change & Forestry: 5B (Sheet 2) Forest conversion for permanent agriculture - Release of non-carbon dioxide GHG from on-site burning of aboveground biomass

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES			
	A	B	C			
Sector Specific Data (units) Land Type	Carbon Released (Gg C)	Nitrogen Released (Gg N)	Emissions Estimates (Gg)			
			CH4	CO	N2O	NOx
On-site burning of above ground biomass	155.19	1.55	***2.483***	***27.158***	***0.017***	***0.617***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5B (Sheet 3) Forest conversion for permanent agriculture - Carbon dioxide release from decay of aboveground biomass

SOURCE AND SINK CATEGORIES				ACTIVITY DATA			EMISSIONS ESTIMATES
				A	B	C	D
Sector Specific Data (units) Land Type				10-year average area converted annually (kha/year)	10-year average annual loss of biomass (kt dm/year)	Average quantity of biomass left to decay (kt dm/year)	Carbon Released from Decay (kt C)
Tropical Forests	Closed Forests	Broadleaf Forests	Logged	5.19	215.18	10.76	4.84
			Unproductive	0.71	118.57	5.93	2.67
	Open Forests	Miombo Woodlands	Productive	46.41	1021.02	51.05	22.97
			Unproductive	13.09	26.18	1.31	0.59
	Open Woodlands	Bushlands and Thickets	Productive	18.10	506.80	25.34	11.40
			Unproductive	5.10	30.60	1.53	0.69
			Total	***88.6***	***1918.35***	***95.92***	***43.163***
Total Carbon dioxide Released (44/12 x C Released)							***158.264***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5B (Sheet 5) Forest and grassland conversion - Total carbon dioxide emissions

CATEGORIES	EMISSIONS (Gg)	
	Carbon	Carbon dioxide
Carbon dioxide release from aboveground burning of biomass	155.190	569.030
Carbon dioxide from decay of aboveground biomass	43.163	158.264
Carbon dioxide from soil carbon release	NA	NA
Total	***198.353***	***727.294***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5C (Sheet 1) Abandonment of Managed Lands - Annual Carbon Uptake from Lands Abandoned Over the Previous 20 Years

SOURCE AND SINK CATEGORIES		AVERAGE ANNUAL TOTAL AREA ABANDONED (PREVIOUS 20 YEARS)			ANNUAL CARBON UPTAKE ESTIMATES		
		A	B	C	D	E	F
		Total Area Abandoned	Annual Rate of Aboveground Biomass Growth	Carbon Fraction of Aboveground Biomass	Aboveground Biomass Carbon Uptake	Soil carbon uptake	Total
Sector Specific Data (units) Land Type		(kha)	(t dm/ha)		(Gg C/yr)	(Gg C/yr)	(Gg C) F=D+E
Tropical Forests	Open forests	35.00	10.00	0.45	157.50		157.500
	Wooded grasslands	205.00	4.00	0.45	369.00		369.000
Total		***240.00***			***526.50***		***526.500***
Total carbon dioxide removal							***1930.500***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5C (Sheet 3) Abandonment of Managed Lands - Total Carbon dioxide Removals

SOURCE AND SINK CATEGORIES	CARBON UPTAKE	CARBONDIOXIDE REMOVALS
	A (kha)	D (Gg CO2) B=Ax(44/12)
Lands abandoned over the previous 20 years	526.50	1930.50
Lands abandoned between 20 and 100 years previously	NA	NA
Total	***526.50***	***1930.50***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5D (Sheet 1) Others - Carbon release from on-site burning of aboveground biomass in shifting cultivation practices

SOURCE AND SINK CATEGORIES	ACTIVITY DATA						EMISSIONS ESTIMATES	
Sector Specific Data Land Type	A Annual area cleared (kha)	B Aboveground biomass cleared (kt dm)	C Aboveground biomass burned on-site (kt dm)	D Fraction of Aboveground biomass oxidized	E Carbon content in biomass	F Nitrogen: Carbon ratio	G Total carbon released (Gg C)	H Total nitrogen released (Gg N)
							G=CxDxE	H=FxG
Miombo woodlands	***55.20***	***552***	***110.40***	0.90	0.45	0.01	***44.712***	***0.447***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5D (Sheet 2) Others - Release of non-carbon dioxide GHG emissions from on-site burning of aboveground biomass in shifting cultivation practices

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES			
Sector Specific Data (units) Land Type	A Carbon Released (Gg C)	B Nitrogen Released (Gg N)	C Emissions Estimates (Gg)			
			CH_4	CO	N_2O	NOx
On-site burning of aboveground biomass	44.712	0.447	***0.715***	***4.173***	***0.005***	***0.138***

STANDARD DATA TABLE 5
Land Use Change & Forestry: 5D (Sheet 3) Others - Methane release from man-made flooded areas (dams)

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES			
Sector Specific Data (units) Land Type	A Total Area Occupied by Dams (kha)	B Fraction Subjected to Annual Floods	C Area Estimated to be Flooded (kha)	D Consecutive Number of Flood Days (Days/yr)	E Total CH4 Released (Gg)
			C=AxB		E=CxDx0.4267)/1000
Man-made water reservoirs	105.30	0.10	10.53	90	0.4044

STANDARD DATA TABLE 6
Waste 6A: Solid waste disposal on land, 6C Waste incineration, and 6D Other solid waste management systems

CATEGORIES	ACTIVITY DATA (Gg)	EMISSION ESTIMATES (Gg)						CH_4 Recovered Gg
	A	B	C	D	E	F	G	N
Disposal Method	Annual DOC disposed	CO_2	CH_4					
A1 Landfills	NO	NA	NO					0.00
A2 Open Dumping	32.58	NA	8.363					0.00
	Quantity of Waste Treated	CO_2	CH_4	N_2O	NOx	CO	NMVOC	
C Waste Incineration	NO	NO	NO	NO	NO	NO	NO	0.00
D Other Wastes								
D1 Sisal Wastes	160.00	NA	30.880	NA	NA	NA	NA	0.00
D1 Coffee husks	4.50	NA	2.228	NA	NA	NA	NA	0.00

STANDARD DATA TABLE 6
Waste 6B: Wastewater Treatment - Industrial, Commercial, and domestic wastewaters

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSION ESTIMATES			Quantity Recovered
	A	B	C	D	E	N
Wastewater Type	Annual average BOD5 generation (Gg BOD5)	Quantity of BOD anaerobically treated (Gg BOD5)	Total methane released (Gg)	Carbon dioxide released (Gg)	Nitrous oxide released (Gg)	Methane (Gg)
B1 Industrial Wastewater	54.369	5.437	1.1961	NA	NA	0.00
B2 Domestic and Commercial Wastewater (sewers + septic tanks)	11.799	1.180	0.2596	NA	NA	0.00
B3 Other (Pit Latrines)	38.798	3.880	0.8535	NA	NA	0.00

APPENDIX 2
Tanzania:
National Greenhouse Gas Inventory for 1990 and 1994

Introduction

The 1990 National Greenhouse Gas (GHG) Inventory for Tanzania was reported by CEEST[1] for the first time in September 1994. Since then a series of versions[2] have been reported at various forums to update the original report using the best available information as a result of evolution of IPCC Guidelines and other works by expert groups of OECD and IEA on methodologies, assumptions, activity data and emission factors. This report follows the 1996 IPCC Revised Guidelines,[3] but the activity data almost remain the same unless stated otherwise.

Basic Approach

The Revised 1990 National Greenhouse Gas Inventory is organized in six main modules: energy, industrial processes, solvents and other products use, agriculture, land-use changes and forestry, and waste. In each module, efforts were made to comply with the 1996 Revised IPCC Guidelines in estimating and reporting relevant GHG emissions and removals by sources or sinks

Target Year

The activity data applied in calculations were either yearly or three year average or twenty year average data representing the actual situation in a Gregorian calendar of 1990, which starts on January 1, and ends on December 31.

Targeted Greenhouse Gases

The major direct GHG including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); and other important radioactive gases which are indirect GHG or ozone precursors including the oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) were targeted. In some cases, few gases controlled by the Montreal Protocol such as sulphur dioxide (SO_2) emissions from energy sub-sectors, as well as halocarbons (HFCs and PFCs) and sulphur hexafluoride (SF_6) emissions from industrial processes and application of solvent are reported as additional information.

Calculating Methods

The GHG emissions and removals were calculated using Equation 1, whereas the activity data are multiplied by relevant emission factors, as expressed below:

$$\text{GHG Emissions} = \Sigma\ (\text{Activity Data x Emission Factor}) \qquad \textit{Equation 1}$$

Most of input data obtained from published national data such as Energy Balance for 1990[4]. The national data were not necessarily the same as internationally published data by OECD/IEA[5], the World Bank or FAO. The source of discrepancies is discussed later while going through the inventory verification process. Most of emission factors were borrowed from IPCC standard data tables except a few in agriculture and waste sectors, which were indicated as footnotes on relevant worksheets.

International Bunkers

CO_2 and non-CO_2 emissions estimates from international bunkers, which include international aviation and marine incoming and outgoing, were included for information only. They do not form part of the national GHG inventory. The methodology used to calculate GHG emissions from international bunkers are the same as explained above for other source. About 353 Gg CO_2, which is almost 12 percent of total CO_2 by the reference approach[3], is attributed to international bunkers.

CO_2 Emissions Estimates from Biomass Fuels

The final energy consumption of Tanzania in 1990, in accordance with the energy balance was dominated by biomass fuels consumption[6,7,8,9,10]. Biomass fuels in the form of wood-fuel, charcoal and other non-woody biomass residues are widely used in households, cottage industries and informal sector. About 67,705 Gg CO_2 emissions from biomass fuels are part of closed carbon cycle, hence they do not form part of the national greenhouse gas inventory but are used to estimate non-CO_2 emissions, which are anthropogenic emissions[3].

CO_2 Emission Estimates by IPCC Reference Approach

Petroleum products export, international bunkers and stock change were excluded from production and imports to establish the inventory of apparent energy consumption. Crude oil import was not disaggregated further into various refined products, hence the estimates of CO_2 emissions by IPCC reference approach provides the maximum CO_2 emissions potential of 2,980 Gg CO_2, based on carbon contents by fuel type, average carbon emission factors, a fraction of carbon oxidised, and a fraction carbon stored.

Estimation of GHG Emissions and Removals by Sectoral Approach

Estimation of GHG emissions and removals by sectoral approach is aimed at creating checks and balances of top-down and bottom-up approaches. It is also useful in identifying those sectors and sub-sectors of priority to the nation, as far as mitigation programme is concerned. Emission factors applied in equation 1 are much more related to the state of art of technologies employed or the best available information. Desegregation of activity data minimizes generalization and increases the quality of estimates.

Energy Sector

The energy sector covers, fuel combustion in utilities and energy transformation into simpler forms, fuel combustion in manufacturing industries and constructions, transport, residential, commerce and other economic sectors, agriculture and fisheries; fugitive emissions from energy systems and coal mining. All activity data were converted from physical to energy units, from which CO_2 emissions by fuel types were estimated at 2,896 Gg CO_2. Compared to 2,980 Gg CO_2 estimated using the Reference Approach, the discrepancy is about 3.2% and it within the tolerable range of ± 10%. The source of discrepancy is probably the difference in emission factors between disaggregated fuels such as refined petroleum products, which are lower, compared to aggregated fuel types such as crude oil, which are much higher.

Energy Industries

Public electricity generation, petroleum refining and charcoal making were the main three sources of GHG emissions. The activity data[1, 8] consist of the domestic energy supply, which comprised of diesel, residue fuel oil, wood-fuel, coal and lubricants. 50% of carbon in lubricants, 2% of carbon in solid fuels, and 1% of carbon in liquid fuels were considered not burning but instead turn into other chemical compounds, soot or char, and therefore were deducted from oxidized carbon. SO_2 emissions were estimated at about 15 Gg while GHG emissions from energy industries are summarized in Table 1.

Table 1: *GHG Emissions from Energy Industries for 1990 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Public Electricity Generation	73.1419	0.0030	0.0006	0.2016	0.0001	0.0050
Petroleum Refining	71.3024	0.0031	0.0006	0.2041	0.0001	0.0051
Charcoal Production	NA	1.6168	0.2156	5.3894	53.8940	2.6947
Total	144.4442	1.6229	0.2168	5.7951	53.8942	2.7048

Making charcoal using unimproved traditional kiln resulted into massive loss of biomass. One tone of charcoal is obtained by combusting six tones of wood-fuel using earth kilns. From the estimates of non-CO_2 emissions in Table 1, it is clear that the impact of charcoal production is significant; hence it should not be ignored.

Manufacturing Industries and Construction

Manufacturing industries in the context this inventory does not strictly follow the International Standard Industrial Classification of All Economic Activities (ISIC). In most cases, the energy consumption statistics did not support ISIC categories. Construction in this context covers application of asphalt (bitumen) on road. Cottage industries[7,8,9] are also inclusive in food, beverage and tobacco, in which biomass consumed. Other fuel combusted include: other kerosene, industrial diesel oil, fuel oil, liquefied petroleum gas, sub-bituminous coal, lubricants, coke oven coke, bitumen, wood-fuel, and baggase. All activity data were converted from physical units into energy units, whereas Equation 1 was used in calculating GHG emissions. The fraction of carbon stored was considered to be 95% for asphalt, 50% for lubricants, 1% for liquid fuels, and 2% for solid fuels. Non-CO_2 emissions were estimated from the total amount of energy consumed. SO_2 emissions were estimated at 15.6 Gg, while GHG emission estimates from manufacturing industries are summarized in Table 2.

Table 2: *GHG Emissions from Manufacturing Industries and Construction for 1990 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Metal and Engineering	157.9755	0.0044	0.0013	0.4350	0.0218	0.0109
Non-metal and Minerals	156.6779	0.0056	0.0014	0.4244	0.0465	0.0129
Chemicals	2.0937	0.0010	0.0003	0.0898	0.0050	0.0023
Pulp, Paper and Printing	107.0641	0.1119	0.0151	0.6772	6.9264	0.1902
Food, Beverage & Tobacco	213.1621	1.5097	0.2022	5.5494	108.108	2.5206
Textiles, Leather & Sisal	85.0331	0.0020	0.0006	0.1882	0.0114	0.0049
Asphalt Application on road	3.2776	0.0016	0.0005	0.1642	0.0082	0.0041
Total	725.2840	1.6361	0.2213	7.5282	115.128	2.7459

Transport

A survey[11] conducted in 1989 indicated that public road transport was the most popular transport mode in most of towns, municipalities and Dar es Salaam City. It was also observed that the source of vehicle imports shifted from European to Japan. Over 50% of operating vehicles are over 10-year old vehicles. A number of four-wheel vehicles in urban areas were alarming. Almost all locomotives were driven be diesel engine, civil aviation was more liberalized with more private companies operating as service providers to remote areas and small towns with small landing facilities.

The activity data[1,11] was not disaggregated by type of vehicle or fuel combustion technology in application. Therefore, Equation 1 was applied as it is, using default emission factors to estimate associated GHG emissions. SO_2 emissions were estimated at 2.7 Gg while the GHG emission estimates are summarized in Table 3.

Table 3: *GHG Emissions from Transport for 1990 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Civil Aviation	149.3436	0.0011	0.0043	0.6410	3.1328	0.1458
Road Transportation	1395.3666	0.1688	0.0117	14.6830	52.7199	7.5064
Railways	127.5723	0.0088	0.0011	2.1098	1.7582	0.3516
Navigation	35.1968	0.0024	0,0003	0.7209	0.4806	0.0961
Total	1707.4794	0.1811	0.0173	18.1547	58.0915	8.1000

The transport sector contributed 59 percent of total CO_2 emissions from the energy sector, most of it attributed to road transport. Non-CO_2 emission estimates are relatively low compared to manufactured industries and construction, the reason being the fact that biomass fuels such as methanol or other blends are not practiced in transport sector.

Other Sectors

For the purpose of this inventory, the sub-heading "other sectors" covers: commercial and institutional sub-sector, residential sector, agriculture, forestry and fisheries. The target fuels include: kerosene, liquefied petroleum gas (LPG), wood-fuel, charcoal and biogas. End-use data were obtained from survey[11] data obtained in 1988 through 1990. SO_2 emissions were estimated at 127 Gg, while the GHG emission estimates were obtained using Equation 1, and are summarized in Table 4.

Table 4: ***GHG Emissions from Other Sectors for 1990 (in Gg)***

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Commercial & Institutions	40.8078	44.7480	0.5954	15.0043	749.1009	89.2099
Residential	225.566	79.0768	1.0362	27.6022	1402.103	154.209
Agriculture/Forestry/Fishing	52.8795	34.0103	0.4538	12.2244	567.4567	68.1541
Total	319.253	158.735	2.0854	54.8309	2718.660	311.573

Biomass fuels are massively consumed in commercial and residential sectors[[7,8,9]. As a result of this, non-CO_2 emissions from commercial and residential sectors were significantly high compared to energy industries, transport sector, and manufacturing industries.

Fugitive Emissions

Fugitive emissions are intentional and unintentional releases of gases from anthropogenic activities. The total release of methane during coal mining and post-mining activities, refining of oil and storage in tanks were estimated and summarized in Table 5. It was not possible to capture all fugitive emissions, except a few. For those areas were information was not available, NA refers "not applicable," NO refers to "not occurring," while NE refers to "not estimated."

Table 5: *Fugitive Emissions from Energy Systems for 1990 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**
Coal Mining & Handling	NA	0.8283	NO	NO	NO	NE	NE
Petroleum Handling	NA	0.0774	NO	0.1572	25.8073	4.2438	1.4690
Total	NA	0.9057	NO	0.1572	25.8073	4.2438	1.4690

Industrial Processes

Total emissions of all greenhouse gases from industrial process where the greenhouse gases are the by-products from transformation of raw material into intermediate of final products have been considered. The emission estimates have been reported where information on quantities of products from various industrial processes is available. The industrial processes are described in subsequent sections. Default emission factors from the 1996 Revised IPCC Guidelines have been used.

Cement Production

Cement manufacture is the most important source of carbon dioxide emissions from non-energy industrial processes. Carbon dioxide (CO_2) and Sulphur dioxide (SO_2) are emitted during the process of cement manufacture. Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made. Almost all the cement produced in Tanzania is the Portland cement type, which contains 68% of lime by weight. Sulphur dioxide emissions originate from clay raw material. In 1990, CO_2 emissions from cement production accounted for 343.8441 Gg while SO_2 emissions accounted only 0.1932 Gg. Worksheets 2.3.1 and 2.3.2 summarise the emissions result for year 1990.

MODULE	**INDUSTRIAL PROCESSES**		
SUB MODULE	**CEMENT PRODUCTION – CO_2**		
WORKSHEET	**2.3.1**		
	STEP 1		
A	**B**	**C**	**D**
Quantity of Clinker or Cement Produced	Emission Factors (t CO_2/t clinker or cement produced)	CO_2 Emitted	CO_2 Emitted
(t)		(t)	(Gg)
		C=(AxB)	$D=C/10^3$
644,144	0.5338	343,844.0672	343.8441

MODULE	INDUSTRIAL PROCESSES		
SUB MODULE	CEMENT PRODUCTION - SO_2		
WORKSHEET	2.3.2		
	STEP 1		STEP 2
A	B	C	D
Quantity of Cement Produced (t)	Emission Factors (Kg SO_2/t cement Produced)	SO_2 Emitted (Kg)	SO_2 Emitted (Gg)
		C=(AxB)	$D=C/10^6$
644,144	0.3000	193,243.200	0.1932

Production of Lime and Limestone Use

Calcinated limestone is formed by heating at high temperatures limestone to decompose the carbonates. The mass of CO_2 produced per unit of lime may be estimated from the molecular weights and the lime content of products. Production of lime reported here is considered for pulp and paper production at the Southern Paper Mills (SPM). CO_2 emission from lime production for pulp and paper production process in 1990 was 5.789 Gg. Worksheet 2.4.1 summarises the emission estimate.

CO_2 produced form limestone use considered here is estimated from data on the production of raw limestone other than that used for cement production, and pulp and paper production. CO_2 emissions from limestone use amounted to 2.015 Gg. Worksheet 2.5.1 summarizes the emission estimate.

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	PRODUCTION OF LIME - CO_2			
WORKSHEET	2.4.1			
	STEP 1			STEP 2
	A	B	C	D
	Quantity of Lime Produced	Emission Factors (t CO_2/t quicklime or dolomite lime produced)	CO_2 Emitted	CO_2 Emitted
Lime Type	(t)		(t)	(Gg)
			C=(AxB)	$D=C/10^3$
Quicklime	7,375	0.7850	5,789.3750	5.7894

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	LIMESTONE AND DOLOMITE USE - CO_2			
WORKSHEET	2.5.1			
	STEP 1			STEP 2
	A	B	C	D
	Quantity of Limestone or Dolomite Used	Emission Factors (Kg CO_2/t limestone or dolomite used)	CO_2 Emitted	CO_2 Emitted
Material Type	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Limestone	4,580	440	2,015,200.000	2.015

Iron and Steel

To date, there is no iron production from iron ore in Tanzania. Iron and steel processing, particularly steel rolling has been considered. Most of the emissions from rolling mills are from the fuel used to heat the process.

NO_x and SO_2 emissions have been estimated, each to be about 0.0004 Gg, while NMVOC emissions were estimated to 0.0003 Gg. Worksheet 2.13.2B to 2.13.2E summarise the emissions results from iron and steel rolling for 1990.

MODULE	INDUSTRIAL PROCESSES		
SUB MODULE	METAL PRODUCTION - IRON AND STEEL NO_x		
WORKSHEET	2.13.2B		
	STEP 1		STEP 2
A	B	C	D
Amount of Iron or Steel Produced	Emission Factors (G NO_X/t of Iron or steel produced)	NO_X Emitted (g)	NO_X Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
9,129	40.0000	365,160.0000	0.0004

MODULE	INDUSTRIAL PROCESSES		
SUB MODULE	METAL PRODUCTION - IRON AND STEEL NMVOC		
WORKSHEET	2.13.2C		
	STEP 1		STEP 2
A	B	C	D
Amount of Iron of Steel Produced	Emission Factors (g NMVOC/t of Iron or steel produced)	NMVOC Emitted	NMVOC Emitted
(t)		(g)	(Gg)
		C=(AxB)	$D=C/10^9$
9,129	30.0000	273,870.0000	0.0003

MODULE	INDUSTRIAL PROCESSES		
SUB MODULE	METAL PRODUCTION – IRON AND STEEL CO		
WORKSHEET	2.13.2D		
			STEP 2
A	B	C	D
Amount of Iron or Steel Produced	Emission Factors (g CO/t of Iron or steel produced)	CO Emitted (g)	CO Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
9,129	1.0000	9,129.0000	0.0000

SUB MODULE	METAL PRODUCTION- IRON AND STEEL SO_2		
WORKSHEET	2.13.2E		
	STEP 1		STEP 2
A	B	C	D
Amount of Iron or Steel Produced	Emission Factors (g SO_2/t of Iron or steel produced)	SO_2 Emitted (g)	SO_2 Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
9,129	45.0000	410,805.0000	0.0004

Pulp and Paper Production

The Southern Paper Mills Company Limited is a fully integrated pulp and paper mill. The major sources of greenhouse gas emissions at the mills include: the power boiler, calcination of limestone to produce lime, and recovery process. The emission estimates are based on total annual production of dried pulp. Emission from lime production from the calcination of limestone process is reported under Lime Production. Worksheets 2.14.1A to 2.14.1D summarize the emissions other than CO_2 emissions from the pulp and paper production process.

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	Pulp and Paper Industries - NO_x			
WORKSHEET	2.14.1A			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg NO_x/t Air dried pulp produced)	NO_x Emitted	NO_x Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	23,332	1.5000	34,998.0000	0.0350

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	Pulp and Paper Industries – NMVOC			
WORKSHEET	2.14.1B			
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg NMVOC/t Air dried pulp produced)	NMVOC Emitted	NMVOC Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	23,332	3.7000	86,328.4000	0.0863

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	Pulp and Paper Industries – CO			
WORKSHEET	2.14.1C			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (Kg CO/t Air dried pulp produced)	CO Emitted	CO Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	23,332	5.6000	130,659.2000	0.1307

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	Pulp and Paper Industries - SO_2			
WORKSHEET	2.14.1D			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg SO_2/t Air dried pulp produced)	SO_2 Emitted	SO_2 Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	23,332	7.0000	163,324.0000	0.1633

Food and Drink Production

Alcoholic beverage, and bread and other food production processes contribute to greenhouse gas emissions. Beer, wine, spirits, biscuits, beef, sugar, margarine and solid cooking fats, coffee roasting and animal feed production, where information is available have been considered to estimate the precursor gas emitted i.e. NMVOC emissions. Total NMVOC emissions for 1990 was estimated to 1.4388 Gg. Worksheets 2.15.1 and 2.15.2 summarize emission estimates from alcoholic beverage and bread and other food production respectively.

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	ALCOHOLIC BEVERAGE PRODUCTION - NMVOC			
WORKSHEET	2.15.1			
	STEP 1			STEP 2
	A	B	C	D
Alcoholic Beverage type	Quantity of Alcoholic Beverage Produced	Emission Factors (kg NMVOC/ hL beverage produced)	NMVOC Emitted	NMVOC Emitted
	(hL)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Spirits (Konyagi)	12,030	15.0000	180,450.0000	0.1805
Beer	450,444	0.0350	15,765.5400	0.0158
Wine	6,250	0.0800	500.0000	0.0005
TOTAL				**0.1967**

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	BREAD AND OTHER FOOD PRODUCTION - NMVOC			
WORKSHEET	2.15.2			
	STEP 1			STEP 2
	A	B	C	D
Food Production Type	Quantity of Food Produced	Emission Factors (kg NMVOC/ t Food produced)	NMVOC Emitted	NMVOC Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Biscuits	1,141	1.000	1,141.000	0.0011
Beef	26,000	0.3000	7,800.000	0.0078
Sugar	107,000	10.0000	1,070,000.000	1.0700
Margarine & Solid cooking fats	13,116	10.0000	131,160.000	0.1312
Coffee roasting	35,800	0.5500	19,690.000	0.0197
Animal feed	12,340	1.0000	12,340.000	0.0123
TOTAL				**1.2421**

Glassware Production

NMVOC emissions from glassware production have been considered. NMVOC emissions are estimated at 0.0597Gg in 1990. Worksheet 2.7.2B summarises the emission estimates.

MODULE	INDUSTRIAL PROCESSES			
SUB MODULE	MANUFACTURE OF OTHER MINERAL PRODUCTS - GLASS -NMVOC			
WORKSHEET	2.7.2B			
	STEP 1			STEP 2
	A	B	C	D
Glass Type	Quantity of Glass Produced	Emission Factors (kg NMVOC/t glass produced)	NMVOC Emitted	NMVOC Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
			-	-
Glassware	13,260	4.5000	59,670.0000	0.0597

Natural Carbon Dioxide Reserves

Tanzania has underground CO_2 and other gases emission at Kyejo in Mbeya region. The emission at Kyejo is a natural process and the gas emitted is composed of 80% CO_2 and 20% other gases.

In recent years, it has been exploited significantly, and the emission is now considered to be man-made. Emission estimates are based on the CO_2 produced. In 1990, about 1.26 Gg of CO_2 were produced.

Emissions from CFCs and Other Greenhouse Gases

Tanzania does not produce Ozone depleting substances (ODS). The consumption estimates reported are based on imports figures and others statistics form different sources. The overall demand forecast for controlled substances is largely influenced by a range of macro economic factors, including growth rate of Gross Domestic Product (GDP), population, and new investments in ODS user sectors. Table 1 shows the consumption of ODS by categories in 1994, estimating the potential emissions from the CFCs.

Table 6: *Consumption of ODS by Sectors and Categories in 1994*

Sector	**Substance**	**Consumption (Tonnes)**	**Ozone Depleting Potential (ODP)**	**Emission Potential (ODP Tonnes)**
Aerosols	CFC-11	75.00	1	75.00
	CFC-12	75.00	1	75.00
Refrigeration & Air Conditioning	CFC-11	30.00	1	30.00
	CFC-12	55.50	1	55.50
	CFC-115	0.60	0.6	0.36
Foams	CFC-11	27.00	1	27.00
Cleaning	Carbon tetrachloride	0.90	1.1	1.0
Fire Fighting	Halon-1301	0.05	10	0.50

Source (2)

Currently, there is no readily available data on HFCs, PFCs, and SF_6 use, which are serving as alternatives to ODS. CFCs usage in the sectors of aerosols, refrigeration and air conditioning, and foams manufacturing will continue to grow steadily up to the year 2010 as projected in Figure 1. Based on the current pattern of ODS use, the use of these substances is currently insignificant. However, with the rapid growth of many cities in Tanzania and the gradual increasing in economic activities, HFCs, PFCs, and SF_6 could be important contributors of greenhouse gas emissions in the future because of their expected extensive use in refrigeration, air conditioning, fire extinguishing, aerosols, solvents and foam production.

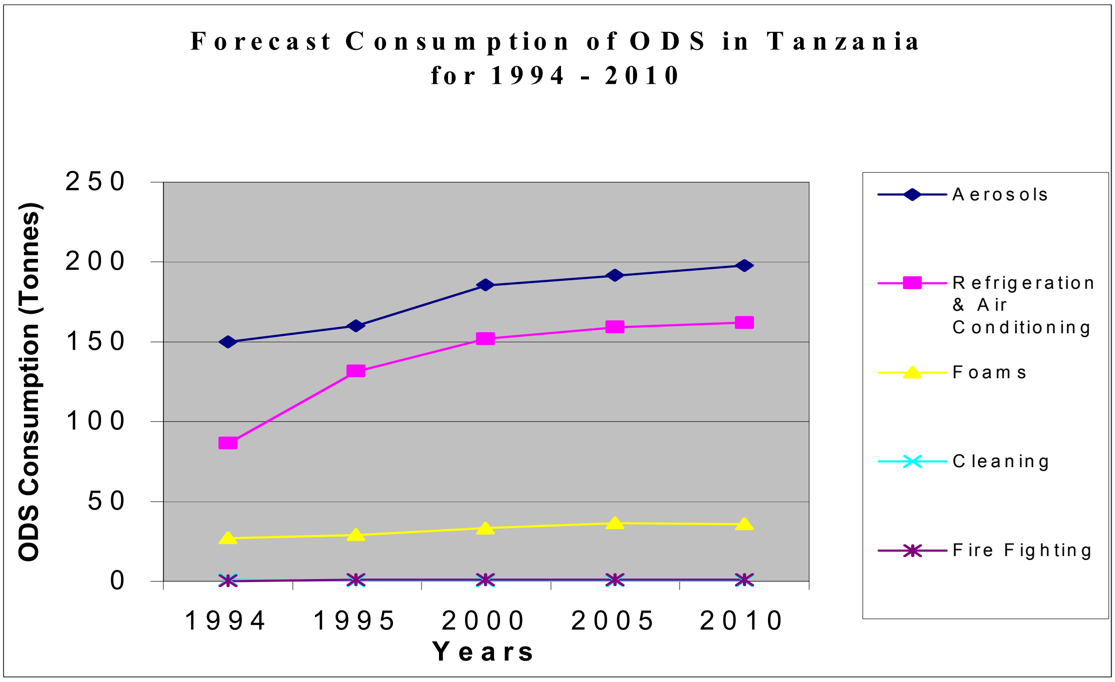

Figure 1

Agriculture

The Tanzanian economy has been and will continue to be heavily dependent on the agriculture sector[12]. The sector is dominated by subsistence agricultural production, which is more labour intensive. Mechanization including irrigation practices is limited to few crops grown in limited geographical areas[13]. Hand-hoe farming is popular throughout all levels starting from farm preparation, ploughing, sowing, to weeding. The use of tractors, animal power, and synthetic fertilizers is for few medium and high-income households. This inventory covers GHG emissions from livestock, rice cultivation, agricultural soils, burning of savannah, and field burning of agricultural residues.

Enteric Fermentation

Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the blood stream[3]. Methane production in herbivores is a by-product of enteric fermentation. Both ruminant (e.g. cattle and sheep) and non-ruminant animals (e.g. pig and horses) produce methane although ruminants are the largest source per unit of feed intake. In this inventory, dairy cattle were limited to pregnant and milked exotic species, the rest were considered to be non-dairy cattle. Activity data in 1990 surveys[14,15,16] and emission factors generated using Tier 1 approach[3] were used to estimate methane from enteric fermentation. FAO data on Table 4-3 of the Work book[3] were high for non-dairy cattle and low for dairy cattle. The results of methane emission estimates are summarized in Table 7.

Table 7: *GHG Emissions from Enteric Fermentation for 1990*

Livestock Type	Number of Animals	Emission Factor	Methane Emissions
	(thousands)	(kg/head/year)	(Gg)
Dairy Cattle	83.900	84.851	7.1190
Non-Dairy Cattle	12962.900	40.887	530.0141
Sheep	5551.400	0.185	1.0270
Goats	8525.900	0.195	1.6626
Mules and Asses	250.000	1.045	0.2613
Swine	275.000	1.000	0.2750
Poultry	21617.500	NA	NA
		Total	540.3589

Manure Management

Methane and nitrous oxide from animal manure management occurs as the result of its decomposition under anaerobic conditions.[3] Methane emissions from animal manure handling were calculated and summarized in Table 8.

Table 8: *CH_4 Emissions from Animal Manure Handling for 1990*

Livestock Type	Number of Animals	Emission Factor	Methane Emissions
	(thousands)	(kg/head/year)	(Gg)
Dairy Cattle	83.900	1.000	0.0839
Non-Dairy Cattle	12962.900	1.000	12.9629
Sheep	5551.400	0.210	1.1658
Goats	8525.900	0.220	1.8757
Mules and Asses	250.000	1.190	0.2975
Swine	275.000	2.000	0.5500
Poultry	21617.500	0.023	0.4972
		Total	17.4330

N_2O emissions were estimated from animal waste management systems such as liquid systems and storage of animal waste in heaps of drylots for more than one month. N_2O emission estimates were calculated and summarised in Table 9.

Table 9: *N_2O Emissions From Animal Manure Management for 1990*

Manure Management	Nitrogen Excretion (Kg N/year)	Emission Factor (kg N_2O-N/ kg N)	N_2O Emissions (Gg)
	A	B	C=(AxB) x 44/28 x 10^{-6}
Liquid Systems	308,000	0.001	0.0005
Solid Storage and Dry lots	21,343,096	0.020	0.6708
			0.6713

Rice Cultivation

The anaerobic decomposition of organic material in flooded rice fields produces methane, which escapes to the atmosphere by bubbling up through water column, diffusion across the water/air interface, and transport through the rice plants[3]. Methane emission estimates from rice cultivation are summarized in Table 10.

Table 10: *Methane Emissions from Rice Cultivation for 1990*

Water Control	Aeration	Area	Scaling Factor	Correction Factor	Emission Factor	CH4 Emissions
		(m^2 x 10^{-9})				(Gg)
Continuous Flooded		0.044	1.0	1.0	20	0.8775
Intermittently Flooded	Single	0.054	0.5	1.0	20	0.5400
	Multiple	0.015	0.2	1.0	20	0.0585
Flooded Prone		2.631	0.8	2.0	20	81.0000
Drought Prone		0.281	0.4	1.0	20	2.2500
	Total	2.825				84.7260

Agricultural Soils

Irrigation practices, climatic variables, soil temperature and humidity influence emissions and removals of CH4 and N2O from agricultural soils. This inventory covers N_2O emissions related to the use of both organic and inorganic fertilisers, biological Nitrogen fixation, and N_2O emissions from human sewage, and leaching. The major challenge had been to collect reliable data. Although the literature provided bits and pieces, the major ones of controversy include the records of nitrogenous fertiliser imports, type and coverage of histosol[15] and estimation of production of pulses and non-nitrogen fixing crop. Further work will be required to ensure that the methodology and activity data are transparent and easily reproducible. The GHG emission estimates from agricultural soils are summarised in Table 11.

Table 11*:* *N_2O Emissions from Agricultural Soils for 1990*

Category	**Source**	**N_2O Emissions (Gg)**
Direct Emissions	Application of Synthetic Fertilisers, Nitrogen Fixing Bacteria, Animal Manure, and Compost	5.342
Indirect Emissions	Leaching of Synthetic Fertilisers and Animal Manure	34.705
	Total	40.047

Prescribed Burning of Savannah

Savannahs are tropical and sub-tropical formations with continuous grass cover, occasionally interrupted by trees and shrubs, which exist in Africa. Savannahs are burned to control the growth of vegetation, remove pests and weeds, promote the nutrient cycle and encourage the growth of new grass for animal grazing. CO_2 from prescribed burning of savannahs is not included in the inventory since it is part of the closed carbon cycle[3]. Emissions of non-CO_2 are included in this inventory. The challenge is how to determine the area subjected to prescribed burning of savannahs[17]. Again, the emission factors are based on experience gained in West Africa and Latin America. The GHG emission estimates from prescribed burning of savannah are summarised in Table 12.

Table 12: ***GHG Emissions from Prescribed Burning of Savannah***

Type of Savannah	Burned Area (kha)	CH_4	N_2O	NOx	CO	NMVOC
Humid	7,800	82.6316	1.0225	36.9584	2169.0789	140.9901
Semi-Arid	4,200	32.5413	0.4027	14.5547	854.2082	55.5235
	12.000	115.1728	1.4253	51.5131	3023.2871	196.5137

Field Burning of Agricultural Residues

Field burning of agricultural residues in this inventory focuses cotton stalks, rice husks and sugarcane leaves. The burning of agricultural waste such as baggase for energy is excluded from the inventory. The activity data were estimated from crop production[1,12], while the emission factors were developed by the local experts and reported in 1994[1]. Non-CO_2 GHG emissions estimate is summarised in Table 13.

Table 13*: GHG Emissions From Field Burning of Agricultural Residues for 1990 (in Gg)*

Source	CH_4	N_2O	Nox	CO
Rice Husks	1.3615	0.0418	1.5112	35.4767
Sugarcane Leaves	0.0339	0.0010	0.0379	0.8902
Cotton Stalks	15.3080	0.4736	17.1169	401.8348
	16.6934	0.5165	18.6660	438.2017

Land-Use, Land-Use Changes and Forestry (LULUCF)

Changes in the use of land often result in changes in the quantity of biomass on land, which produce a net change in greenhouse gas emission. Since biomass is about 45 percent carbon by weight, extensive forest clearing by felling trees indiscriminately leads to accumulation of carbon dioxide in the atmosphere. Clearing vegetation cover by burning also leads to instantaneous releases of not only carbon dioxide but also methane, carbon monoxide, nitrous oxide and nitrogen oxides, NMVOCs are also emitted in significant quantities from biomass burning, but are not treated due to the lack of IPCC Guidelines on NMVOCs. In the case of carbon dioxide however, we are concerned with the releases since re-growth of vegetation cover leads to removal of CO_2 accumulated in atmosphere through photosynthesis.

Soil disturbance does lead to substantial quantities of delayed GHG emissions. Forest conversion into pasture or cropland results in release of soil carbon through oxidation of organic matter contained in the soil. Soil also a natural sink of methane, nitrous oxide, and carbon by bio-fixation process. Through drainage or filling freshwater wetlands increase methane and carbon dioxide emissions by oxidation of soil organic matter.

This section covers estimation of emission of Greenhouse gases from land-use and forestry sector in Tanzania. Important categories of land-use change activities which contribute to emission of greenhouse gases that were considered include:-

- Changes in forest and other woody biomass stocks, which include commercial management, harvest of industrial round-wood (logs) and fuel-wood, production and use of wood commodities, and establishment and operation of forest plantations as well as planting trees in urban and village areas;
- Forest and grassland conversion to pastures, cropland, or other managed uses, which can significantly change carbon stored in vegetation and soil;
- Abandonment of croplands, pastures, plantation forests, or other managed lands which re-grow into their prior natural grassland or forest conditions; and
- Change in soil carbon following any new forest management or agricultural practice.

Ecosystem categories have been established based on conventions common in the literature. Table 14 shows the categories based on the FAO system to be consistent with the tables of default values.

Table 14: *Typical Tropical Forests and Grassland Categories*

Descriptive parameter	**Wet**	**Moist with short dry season**	**Moist with long dry season**	**Dry**	**Montane Moist**	**Montane Dry**
Mean Annual Rainfall (mm)	>2000	2000 >R >1000		< 1000	>1000	< 1000
Mean Annual Temperature	> 20°C	> 20°C, < 5 months dry	>20, < 5 months dry	> 20°C	≤ 20°C	≤ 20°C
Vegetation	Mainly evergreen	Mainly moist deciduous	Mainly dry deciduous	very dry deciduous	mainly evergreen	mainly dry deciduous
Closed formations	Lowland rain forest	Lowland evergreen to semi-deciduous forest	Dry deciduous forests and miombo woodlands	Deciduous forest and woodlands, very dry savannas and steppe	Montane evergreen forest	Scrub forests and evergreen to semi-evergreen thickets
Aboveground cover biomass (tonnes dm/kha)	300	140	75	38	105	40
Open formations	Mainly evergreen degraded	Mainly moist deciduous	Mainly woodland and tree savannas	dry woodland and tree savannas	mainly degraded evergreen and seasonal	mainly dry savannas

Source: ([1])

Carbon Dioxide

Vegetation withdraws CO_2 from the atmosphere through the process of photosynthesis. CO_2 is in turn releases to the atmosphere by the respiration of the vegetation (autotrophic) and decays of organic matter in soils and litter (heterotrophic respiration). In the absence of significant human disturbance, the gross fluxes of CO_2 from the atmosphere to the terrestrial biosphere are thought to be balanced by the return respiration fluxes.

Land use change and use of forests directly alters these fluxes, their balance, and consequently the amount of carbon stored in living vegetation, litter, and soils. The fundamental basis for the CO_2 methodology rests upon the following:

- The flux of CO_2 to and from the atmosphere is assumed to be equal to changes in carbon stocks in existing biomass and soils, and
- Changes in carbon stocks can be estimated by first establishing rates of change in and use and the practice used to bring about the change (e.g. burning, clear-cutting, etc.).

The following paragraphs provide detailed information on methodology, assumptions and data used in calculations.

Changes in Forest and Other Woody Biomass Stocks

Natural, undisturbed forests, where they still exist and are in equilibrium were not considered either as an anthropogenic source or sink. In practice, very little forests and woody biomass stocks are not subject to human induced GHG emissions or removals. However, at present, the understanding of these broad effects is so uncertain, and quantitative estimation so difficult, that they are not included in the basic calculations. Some of the activities in the changes in forest and other woody biomass stocks category, which can potentially produce significant carbon fluxes, are:

- Management of commercial forests including logging, restocking, and selective thinning, as practised by commercial forest products industries;
- Establishment and management of commercial plantations through aforestation or reforestation;
- Other aforestation and reforestation programmes; and
- Informal fuel-wood gathering.

Village and farm trees, urban trees, and trees planted along highways allow users to account for biomass in trees outside normal forest, and they are included in the calculations. The following assumptions were made in calculations:

- All carbon in biomass harvested is oxidised in the removal year;
- New forest products with long lifetimes from current harvests frequently replace existing product stocks, which are in turn discarded and oxidised;
- The net growth of biomass stocks and accumulation of carbon depend on the type of biomass stock and the intensity of harvesting;
- About 1,000 planted trees in villages and urban areas can be accommodated in one hectare; and
- A general default value of 0.50 tonnes- C/tonne dry biomass was considered.

Table 15: *Annual Carbon Accumulation in Growing Woody Biomass Stock*

MODULE	LAND USE CHANGE IN FORESTRY						
SUBMODULE	CHANGES IN FOREST AND OTHER WOOD BIOMASS STOCKS						
WORKSHEET	5 - 2- 1						
SHEET	1 OF 3						
			STEP 1				
			A	B	C	D	E
			Area of Forest/Biomass Stocks	Annual Growth Rate	Annual Biomass Increment	Carbon Fraction of Dry Matter	Total Carbon Uptake Increment
			(kha)	(t dm/ha)	(kt dm)	(kt C/kt dm)	(kt C)
					C=(AxB)		E=(CxD)
Tropical	Plantation	Acacia spp.	0.4	15.0	6.0	0.5	3.00
		Eucalyptus spp.	3.8	14.5	55.1	0.5	27.55
		Tectona grandis	2.6	8.0	20.8	0.5	10.40
		Pinus spp.	44.4	11.5	510.6	0.5	255.30
		Pinus caribaea	7.7	10.0	77.0	0.5	38.50
		Mixed Hardwoods	3.0	6.8	20.4	0.5	10.20
		Mixed fast Growing Hardwoods	6.2	12.5	77.5	0.5	38.75
		Mixed Softwoods	11.2	14.5	162.4	0.5	81.20
	Other Forest	Moist					
	Non-Forest Trees		Number of Trees Survived (in 1000s)	Annual Growth Rate (t dm/ha)	Annual Biomass Increment (kt dm)	Carbon Fraction of Carbon (kt C/kt dm)	Total Carbon Uptake Increment (kt C)
Woodlot			79,000	14.5	1145.5	0.5	572.75
Tree Planting Programmes			120,000	14.5	1740	0.5	870
Village aforestation			140,000	14.5	2030	0.5	1015
						Total	**2919.65**

The results from Table 15 are related to the results from Table 16 on annual harvest from stocks in order to determine the net annual amount of carbon uptake (as negative) or release (as emissions).

Table 16: ***Amount of Woody Biomass Consumption in 1990***

MODULE	LAND USE CHANGE IN FORESTRY							
SUBMODULE	**CHANGES IN FOREST AND OTHER WOOD BIOMASS STOCKS**							
WORKSHEET	**5 - 2- 1**							
SHEET	2 OF 3							
				STEP 2				
	F	G	H	I	J	K	L	M
Harvest Category (specify)	Commercial Harvest (if Applicable)	Biomass Conversion/ Expansion Ratio (if Applicable)	Total Biomass Removed in Commercial Harvest	Total Traditional Fuelwood Consumed FAO data	Total Other Wood use	Total Biomass Consumption	Wood Removed From Forest Clearing	Total Biomass Consumption From Stocks
	(1000m^3 roundwood)	(t dm/m)	(kt dm)	(kt dm)	(kt dm)	(kt dm)	(kt dm)	(kt dm)
			H=(FxG)			K=(H+I+J)		M=K-L
Timber	508	0.95	482.60	0	360	842.60		
Fuel wood	0	0.88	0	31055.33	0	31055.33		
Charcoal	0	0.88	0	3982.60	0	3982.60		
Wood-poles	631	0.95	599.45	0.00	1	600.45		
						36480.98	0	36480.98

Table 17: ***Net Annual Amount of Carbon Uptake or Release***

MODULE	LAND USE CHANGE IN FORESTRY		
SUBMODULE	**CHANGES IN FOREST AND OTHER WOOD BIOMASS STOCKS**		
WORKSHEET	**5 - 2 –1**		
SHEET	3 OF 3		
		STEP 3	
N	O	P	Q
Carbon Fraction	Annual Carbon Release (kt C)	Net Annual Carbon Uptake (+) or Release (-)	Convert to CO2 Annual Emission (-) or removal (+)
	O=(MXN)	P=(E-O)	Q=(PX[44/12])
0.5	18240.491	-15320.84	-56176.417

Table 17 shows that about 56176.417 Gg of CO_2 emissions were emitted/removed in 1990. In previous study, the calculation results indicated the net carbon emissions equivalent to about 54,123 Gg CO_2. Table 18 shows zones potentially experiencing environmental stress due mismanaged harvest of forests and other woody biomass.

Table 18: ***Zones Identified in Terms of Environmental Stress***

Zone	Brief Description	Geographical Location
I	Areas of high population pressure on land for farming and on woodfuel with subsequent deforestation, high risk of erosion due to terrain and high rainfall.	East and West Usambara, Kilimanjaro and Meru Mountain slopes, Kagera, Rungwe, Ukerewe, Tarime and Mbulu
II	Area of high population with extensive agriculture for cotton accompanied with overgrazing.	Mwanza, Mara and some parts of Shinyanga.
III	Areas characterised by overgrazing and migratory pastoralists.	Masai Steppe, parts of Dodoma and Singida.
IV	Area of high population with extensive agriculture for cotton accompanied with overgrazing, with extensive agriculture for tobacco production	Tabora Region, Chunya and Northern Iringa Districts.
V	The grain basket of Tanzania growing maize for commercial purpose.	Southern Rukwa, Northern and Western Ruvuma, Iringa and Mbeya Regions.
VI	High population pressure due to refugees and immigrants from Burundi and Rwanda	Kagera and Kigoma Regions.
VII	Degraded lands under "Hifadhi Ardhi Shinyanga (HASHI) and "Hifadhi Ardhi Dodoma (HADO)"	Shinyanga and Dodoma Regions
VIII	Relatively sparsely populated parts of the country still with abundance of wood supplies.	Eastern Ruvuma (Tunduru), Southern Morogoro (Mahenge District), South of Coast Region (Utete District), Lindi and Mtwara.
IX	Salt production and fish smoking cause forest degradation	The whole coastal belt and Mafia Island
X	Commercial fuelwood belt, charcoal burning, firewood and shifting cultivation	Eastern Morogoro, Coast Region except Rufiji, West of Tanga and South Eastern Dodoma Region.

Source :([27])

Forest and Grassland Conversion for Agricultural Lands

Although the problem of loss of forestland is acknowledged in Tanzania, figures on its extent and rate vary considerably. For example, while the Tanzania Forest Action Plan reports deforestation rate of 300,000 to 400,000 hectares per annum due solely to clearing for agriculture to increase food production, other researchers have been quoting the same figure as a gross deforestation rate attributed to all reasons leading to annual loss of forestland, and others qualifying the latter to range from 0.7 to 1.5 million hectares[7,]. In this study, attempt has been made to do justice to these figures and clear the inconsistencies. Table 19 shows the long-term dynamism of forests, and is an extract of Table 2-1.

Table 19: Changes in Tropical Vegetation during 1947-1990 (unit in kha)

Vegetation Type	1947	1956	1976	1980	1990
Wet/Very Moist (Mangrove)	93	80	80	80	80
Moist, short dry season (Closed Forest)	7727	1885	1455	668	626
Moist, long dry season (Miombo Woodlands)	35392	38706	26702	15738	13502
Dry, long dry season (Bushlands/Thickets)	9481	10551	9878	13678	12375
Moist, Montane (Thickets)	772	569	727	3055	2705
Total	53465	51791	38842	33139	29208

Source: ([1, 21])

During 1947-1956, annual deforestation rate was 186,000 hectares. This figure increased to about 1.2 million hectares during 1956-1976, dropped to about 1.1 million hectares during 1976-1980, and dropped further to 393 ha during 1980-1990. Thus, it depends on which period a researcher is focusing on; otherwise, the figures on annual deforestation rate are likely to differ. "Snap shot" figures may not portray the actual picture as they tend to underestimate or overestimate the actual values.

The reasons for an increase in annual deforestation rate during 1956-1976 may include: tsetse fly eradication; massive expansion of cotton and tobacco cultivation accompanied by overgrazing; "Ujamaa" villagisation campaigns during 1967-1972; and the 1972-1974 nation-wide crash programme in increasing food crop production. During 1956-1976, about 300,000 to 400,000 hectares of closed and open forests were cleared for food crop production; some 130,000 hectares for cash crop cultivation; and another 300,000 to 400,000 hectares for fuel-wood supplies to meet the needs for cooking, fish smoking, brick making, and salt drying[7].

The decline in annual deforestation rate during 1980-1990 may be attributed to a combination of factors including: the change of macro-policies; under-capacity utilisation of agro-industries; introduction of subsidies on fertilisers, kerosene and electricity; abandonment of large-scale plantations; decline in prices of cash crops; to significant increase in distances between the fuel-wood supply side and market side. It is estimated that 393 ha of forests were cleared for permanent agricultural land and pastures in 1990. Tables 20 and 21 show carbon release calculations due to clearance of forests and grasslands for permanent agricultural land and pastures.

Table 20: *Biomass Lost during Forest Clearing for Agriculture in 1990*

MODULE		**LAND USE CHANGE IN FORESTRY**				
SUBMODULE		**FOREST AND GRASSLAND CONVERSION - CO_2 FROM BIOMASS**				
WORKSHEET		**5 - 3 –1**				
SHEET		1 OF 5 BIOMASS CLEARED				
				STEP 1		
		A	B	C	D	E
		Area Converted Annually	Biomass Before Conversion	Biomass After Conversion	Net Change in Biomass Density	Annual loss of Biomass
		(kha)	(t dm/ha)	(t dm/ha)	(t dm/ha)	(kt dm)
Land types					D= (B - C)	E = (A x D)
Tropical	Moist, Short dry season	626.00	140	18	122	76372
	Moist, long dry season	13503.00	75	10	65	877695
	Dry	12374.60	37.5	4	33.5	414549.1
	Montane Moist	2705.20	105	18	87	235352.4
	Montane Dry	329.50	40	4	36	11862
Tropical Savanna / Grasslands		14878.13	60	50	10	148781.3
Subtotals		44416.43				1764611.8

Notes: (1) The grassland area, which was converted into agricultural land and pasture, was derived from a 25-year change in grassland.

(2) The forest area, which was converted into agricultural land, was derived from a 10-year change in forests.

The following assumptions were made on characteristics of above-ground biomass cleared for permanent agricultural land and pastures:

- Not all aboveground biomass is burned. About 75% of total cleared aboveground biomass is collected as fuel-wood. Approximately 20% of aboveground biomass is burned on-site (of which 90% of burned carbon oxidises and 10% remains on ground as charcoal), and the remaining 5% of aboveground biomass decays slowly in fields (usually over the average of 10 years) releasing one-tenth of its carbon content on dry weight basis annually;
- Above-ground biomass densities before conversion of forests were borrowed from default IPCC 1995 figures and assumptions as revised; and
- Aboveground biomass densities were borrowed from Openshaw[21].

Table 21: *Carbon Released by Burning Aboveground Biomass On-Site*

Vegetation Type		Quantity of Biomass Burned On-Site (kt dm)	Fraction of Biomass Oxidised On-Site	Carbon Fraction of Aboveground Biomass (t C/t dm)	Quantity of Carbon Released On-Site (kt C)
Tropical	Moist, short dry season	102.48	0.90	0.50	46.116
	Moist, long dry season	2683.20	0.90	0.50	1207.440
	Dry	886.04	0.90	0.50	398.268
	Montane Moist	607.26	0.90	0.50	273.267
Tropical Savannas/Grassland		499.20	0.90	0.45	202.176
Total		4278.98			2127.717

Aboveground biomass, which is collected from fields as fuel-wood, was calculated at 16,046 kt dm. This amount is assumed to have been used within the same year to offset the growing fuelwood needs, which is calculated at 35,038 kt dm for 1990. The emissions related to its burning off-site have been accounted under the energy section of this report. For completeness, the amount of carbon burned off-site is provided on Table 22.

Table 22: *Carbon Released by Burning Aboveground Biomass Off-Site*

Vegetation Type		Quantity of Biomass Burned Off-Site (kt dm)	Fraction of Biomass Oxidised Off-Site	Carbon Fraction of Aboveground Biomass (t C/t dm)	Quantity of Carbon Released Off-Site (kt C)
Tropical	Moist, short dry season	384.30	0.90	0.50	172.935
	Moist, long dry season	10062.00	0.90	0.50	4527.900
	Dry	3322.65	0.90	0.50	1495.193
	Montane Moist	2277.23	0.90	0.50	1024.754
Total		16046.18			7220.782

Note: These figures are for information only; they appear in other form under the Energy section.

Table 23 shows calculations of carbon released by decaying aboveground biomass in fields over a decade. Since the figures used on Table 20 are 10-year average area of converted forest and grasslands, Table 24 focuses on 5% of the total cleared aboveground biomass, which is equivalent to one-tenth of carbon released annually from decaying organic matter. Decaying is a biological process in the presence of oxygen, involving the conversion of plant cellulose into CO_2, water vapour and amino acids. The conversion process is mainly oxidation at a rate of about 90 percent.

Table 23: *Carbon Released by Decaying Aboveground Biomass On-Site*

Vegetation Type		Quantity of Biomass Decayed On-Site	Fraction of Biomass Oxidised On-Site	Carbon Fraction of Aboveground Biomass	Quantity of Carbon Released On-Site
		(kt dm)		(t C/t dm)	(kt C)
Tropical	Moist, short dry season	25.62	0.90	0.50	11.529
	Moist, long dry season	678.80	0.90	0.50	305.460
	Dry	221.21	0.90	0.50	99.544
	Montane Moist	151.81	0.90	0.50	68.315
Total		1077.44			484.848

The results of carbon release calculations on Tables 21 and 23 were added to determine the total carbon release from conversion of forests and grassland from permanent agricultural land and pastures. Table 24 shows the total annual release of carbon due to forest and grassland conversion.

In previous study, the total annual release of carbon from clearance of forests and grasslands was estimated at 727 Gg CO_2. The current figure of about 9,579 Gg CO_2., is a significant increase based on an increase in converted area.

Table 24: *Carbon Releases by Conversion of Forests and Grasslands in 1990*

Vegetation Type		Immediate Release from Burning Aboveground Biomass On-Site	Emissions from Decaying Aboveground Biomass On-Site	Total Annual Carbon Releases On-Site	Molecular Weight conversion Factor, equivalent to 44/12	Total Annual CO_2 Releases On-Site
			(kt C)			(Gg CO_2)
Tropical	Moist, short dry season	46.116	11.529	57.645	3.6667	211.365
	Moist, long dry season	1207.440	305.460	1512.900	3.6667	5547.300
	Dry	398.268	99.544	497.812	3.6667	1825.311
	Montane Moist	273.267	68.315	341.582	3.6667	1252.467
Tropical Savannas/Grasslands		202.176	0	202.176	3.6667	741.312
Total		2127.717	484.848	2612.565		9579.405

Abandoned Managed Lands

Abandoned managed lands were evaluated in the context of the various natural ecosystems originally occupying them. A twenty five year historical time horizon was considered to capture the more rapid growth of vegetation expected after abandonment. To estimate gains in biomass carbon stocks the total area abandoned (total over the previous 20 years including the inventory year) was multiplied by the average annual uptake of carbon in the aboveground biomass. It is clear that most of forest systems will take longer than 100 years to return to the level of biomass contained in an undisturbed state, but data to cover the whole period is not readily available. It is also clear that the growth rates of aboveground biomass in forests abandoned over 20 years ago would be slower than those of forests re-growing from abandonment that occurred less than 20 years ago.

With the change in land ownership policies, marketing policies and decline in producer prices in the world commodity markets, a substantial part of sisal and cashew trees plantations were abandoned in the late sixties and in the seventies. It is estimated that 35 kha of cashew tree farms in Lindi, Mtwara and Coast regions, and 205 kha of sisal estates in Morogoro and Tanga were abandoned and left to re-grow naturally during the mid sixties and early seventies. These are the only two types of abandoned managed lands on which some information has been obtained and are the only ones considered here. The following is a number of assumptions were made so as to arrive at carbon removal estimates:

- Almost all the abandoned managed lands allowed natural re-accumulation of carbon, and such re-accumulated biomass created a net uptake of atmospheric CO_2;
- The identified areas were abandoned in the last 25 years, whereas 35 kha of cashew tree plantations were re-grown into moist vegetation with short dry season (i.e. woodland), while the sisal estates re-grew into tropical savanna (i.e. grassland);
- The annual average aboveground biomass growth by natural regeneration within the last 20 years for moist with short dry season and tropical savanna is about 5.3 and 2.4 t dm/ha, respectively; and
- The annual average aboveground biomass growth by natural regeneration above 20 years for moist with short dry season and tropical savanna is about 1.3 and 1.8 t dm/ha, respectively.

Table 25 shows carbon uptake calculations for the first twenty years of re-growth:

Table 25: *Carbon Uptake by Aboveground Biomass Re-growth - First 20 Years*

Vegetation Type	20-Year Total Area Abandoned and Regrowing	Annual Rate of Aboveground Biomass Growth	Carbon Fraction of Aboveground Biomass	Annual Carbon Uptake in Aboveground Biomass
	(kha)	(t dm/ha)	(t C/t dm)	(kt C)
Tropical moist, short dry season	35	5.3	0.50	92.75
Tropical Savannas/Grasslands	205	2.4	0.45	221.40
Total	240			314.15

Likewise, Table 26 shows carbon uptake calculations for the period beyond 20 years of re-growth:

Table 26: *Carbon Uptake by Aboveground Biomass Re-growth - Beyond 20 Years*

Vegetation Type	Total Area Abandoned for more than twenty years	Annual Rate of Aboveground Biomass Growth	Carbon Fraction of Aboveground Biomass	Annual Carbon Uptake in Aboveground Biomass
	(kha)	(t dm/ha)	(t C/t dm)	(kt C)
Tropical Moist, short dry season	35	1.3	0.50	22.75
Tropical Savannas/Grasslands	205	1.8	0.45	166.05
Total	240			188.80

Table 27 combines the results of Table 25 and 26 and shows carbon uptake calculations by abandoned managed land assumed to re-grow naturally for 20 years and above.

In a previous study, an uptake due to abandonment of managed land was estimated at 1,931 Gg CO_2, which is more or less comparable to 1,844 Gg in this study. The discrepancies are due to the refinement of annual rate of aboveground biomass, as revised.

Table 27: *Carbon Uptake due to Abandonment of Land - 20 Years and Beyond*

Vegetation Type	Total Area Abandoned for 20 years and beyond	Annual Carbon Uptake in Aboveground Biomass	Molecular Weight Ratio, 44/12	Annual Carbon Uptake in Aboveground Biomass
	(kha)	(kt C)		(kt C)
Tropical Moist, short dry season	35	115.50	3.6667	423.50
Tropical Savannas/Grasslands	205	387.45	3.6667	1420.65
Total	240	502.95		1844.15

Emissions or Uptake by Soil From Land-Use Change and Management

The principal sources and sinks of CO_2 in soils are associated with changes in the amount of organic carbon stored in soils. Fundamentally, changes in inorganic carbon content are a function of the balance between the inputs to soil of photosynthetically fixed carbon and losses of soil carbon via decomposition. For soils, both the quality and quantity of organic matter inputs and the rate of decomposition of soil organic carbon will be determined by the interaction of climate, soil and land-use management, including land-use history.

In agricultural systems, land-use management acts to modify both the input of organic matter via residue production, crop selection, soil tillage, mulching, irrigation, fertilisation, harvest procedures, residue management, and the rate of decomposition. In this study, estimates of CO_2 fluxes were made indirectly through balance estimates of the net change in carbon stocks of the soil. The following paragraphs cover a number of land-use management systems of importance in the context of this study.

Land Clearing From Native Vegetation

The clearing of native vegetation (e.g. forests, savannah, grassland and wetlands) to agricultural land almost invariably leads to a reduction in soil carbon as a result of decreased carbon inputs and enhanced decomposition from the disturbed soil. Generally, the majority of losses occur within the first 10 years although slower declines in soil carbon can continue for many decades. Literature shows losses of 20 to 40 percent or more of the original soil carbon stock following cultivation. Default average reductions in soil carbon stock of about 40 percent for the surface (0-15 cm) and about 30 percent for the top 30 cm.

Shifting Cultivation or "Slash and Burn" Practice

Shifting cultivation systems are characterised by a cycle of forest and bush clearing, followed by a few years of cropping and then abandonment to allow natural re-vegetation (i.e. fallow). Abandonment of land occurs as an integral phase of shifting cultivation. Soil carbon is rapidly lost during the cropping phase and re-accumulates during fallow. The loss of 8 t C/ha from soils (0-40 cm) within 2 years of forest conversion has been reported[1]. Again recoveries to native soil carbon levels after about 10 years of bush fallow follow a two to six year cultivation cycle, by which time vegetation had not nearly attained native size or composition.

Shifting cultivation has had a marked impact in the tobacco growing areas of Tabora, Urambo, Iringa, Chunya and Songea districts. Because of soil infertility, nematode infestation and fuel-wood shortage for curing tobacco leaves, extensive areas are cleared annually and abandoned after about three years of cultivation. It is estimated that one hectare of woodland (50-60 m^3 of solid wood) is needed for every hectare of tobacco or 450 kilograms of cured leaf[7]. Of the three types of tobacco (i.e. flue-cured, fire-cured and burley), fire-cured tobacco showed a consistent increase in area cultivated averaging 71% (i.e. from 228,000 ha in 1985/86 to 1,374,000 ha in 1991/92). The largest increase for fire-cured tobacco was in the year 1990/91 when a positive change of 112% was recorded[27]. The implication of the increase in area under cultivation as yield declines to encourage extensive cultivation, thus clearing more land to maintain output levels.

Tillage

Intensive soil tillage is recognised as a significant factor causing soil inversion, enhances decomposition by releasing organic matter protected within soil aggregates and by increasing soil temperature. Reduced tillage and particularly "no-till" practices have shown a 0-30 percent carbon increase and promote higher levels of organic matter in many systems, where productivity and organic matter inputs are not adversely affected.

Residue Inputs, Mulching and Cover Crops

Maintenance of soil carbon depends on an adequate return of organic substrates, which serve as the raw material for organic matter formation. In most agricultural systems, the primary sources of raw carbon are crop residues. The amount of carbon returned in the form of residues depends on the total biomass yield and the proportion of that biomass which is exported from the fields. The rate of composition, and the proportion of carbon retained by soil, is however, influenced by climate, soil conditions, placement and the composition of the residue. The following paragraphs are focusing on the methodology for estimation of CO_2 flux from agricultural soils.

Estimation of CO_2 Flux from Agricultural Soils

Two potential sources of CO_2 emissions from agricultural soils are considered here: 1) net changes in organic carbon stocks of mineral soil associated with changes in the land-use and management, and 2) emissions of CO_2 from cultivated organic soils (i.e. histosols). The following assumption were made for the former:

- Net carbon fluxes are calculated on the basis of changes in carbon stocks over a twenty-year period. Due to lack of data in this study, a 15 year period is used;
- For mineral soils, only the top 30 cm are considered, which typically has the highest concentration of carbon and the greatest response to changes in management and land-use;
- Negative calculation results represent a net decline in soil carbon stocks, hence a net emission or source of carbon to the atmosphere;
- Positive calculation results represent a net sequestration or sink of carbon in soil, over the 15-year inventory period. To derive current net annual emissions the final total is divided by 15;

Calculation of organic soils (i.e. histosols) to agricultural land is normally accompanied by artificial drainage and cultivation, resulting in rapid oxidation of organic matter and soil subsidence. The rate of carbon release will depend on climate, the composition of organic matter, the degree of drainage and other practices such as fertilisation. Use of organic soils for upland crops (e.g. grains and vegetables) give greater carbon losses than for conversion to pasture or forest, due to deeper drainage and more intensive management practices, such as cultivation.

Table 28: *Net Changes in Carbon Storage in Mineral Soils*

Land-Use	Soil Type	Soil C-managed (t C/ha) per 15	Land Area in 1976	Land Area in 1990	C Stock in 1976	C Stock in 1990	Net C-stock change in soil
			(Mha)	(Mha)	(Tg)	(Tg)	(Tg per year)
1. Shifting Cultivation with Short fallow	High Activity	54	0.3	0.4	16.2	21.6	0.36
	Low Activity	27	1.0	1.1	27.0	29.7	0.18
	Wetland Soils	54	0.1	0.0	5.4	0.0	-0.36
2. Mixed Continuous Cropping	High Activity	51	0.8	0.9	40.8	45.9	0.34
	Low Activity	24	2.7	2.4	64.8	57.6	- 0.48
	Volcanic Soils	51	0.2	0.2	10.2	10.2	0.00
3. Irrigated Cropland and Wetland Paddy	High Activity	51	0.0	0.1	0.0	5.1	0.34
	Low Activity	18	0.1	0.1	1.8	1.8	0.00
	Wetland Soils	134	0.2	0.2	26.8	26.8	0.00
Total			5.4	5.4			0.38

Sources: ([1, 7, 21])

Notes: (1) Soil $_{C\ managed}$ values were determined and adjusted accordingly.

(2) The 1976 C-stock were subtracted from the 1990 C-stock values to obtain the net C-stock change

The following assumptions were made in the course of calculating emissions potential:

- The rate used for cropland (i.e. 20 t C/ha/year) is twice that for the warm temperate zone, which is similar to the rates reported for subtropical Florida (i.e. 21.9 t C/ha/yr);
- Carbon loss rates from conversions to pasture are a quarter of those under cropland within each climate region;
- Out of cultivated land estimated at 5.4 million hectares, about 8.8 kha were organic soils;
- Out of 8.8 kha of organic soil, upland cropland accounts for 5.4 kha, while about 3.4 kha were under fallow, of which some were re-growing into forests and the remaining turned into pastures; and
- Carbon release values were calculated on an annual basis.

Table 29: *Net Carbon Losses from Disturbed Organic Soils in 1990*

Use of Organic Soil	Land Area	Annual Rate Loss	Net Carbon Loss
	(kha)	(t C/ha/year)	(kt C)
Upland Cropland (grain and vegetables)	5.40	20	108
Fallow turned into Pastures/Forest	3.40	5	17
Total	8.80		125

Table 29 shows carbon release calculation results based on the assumptions made above.
The total annual carbon dioxide fluxes from agriculturally impacted soils are calculated from Tables 28 and 29. The results are shown on Table 30.

Table 30: *Total CO_2 Fluxes from Agriculturally Impacted Soils*

Source	Net Carbon Uptake/Release	Molecular Weight Ratio, estimated at 44/12	Total Annual CO_2 Emissions/ Uptake
	(kt C)		(Gg)
Net Change in Soil Carbon in Mineral Soils	-380	3.6667	-1393.333
Net Carbon Loss from Organic Soils	125	3.6667	458.333
Total	-255		-935.000

Note: The negative value refers to a net uptake of carbon dioxide.

From the summary of calculation results on Table 30, total carbon dioxide fluxes from agriculturally impacted soils created a net uptake or removal of about 935 Gg. Due to the lack of methodology and emission factors, agriculturally impacted soil was ignored in the previous study.

Methane

Where there is open burning associated with aboveground biomass from cleared forest and grassland or anaerobic decomposition of aboveground biomass, it is important to estimate the emissions of methane. The approach is the same as that used for methane for all burning and anaerobic decomposition in previous sections. In the proposed methodology, crude estimate of methane emissions can be based on ratios to the total carbon released.

Onsite Burning of Aboveground Biomass

The carbon trace gas releases (CH_4 and CO) are treated as direct ratios to total carbon released. Emission ratios vary significantly between the flaming and smouldering phases of fire. CO and CH_4 are mainly emitted during the smouderling stage of on-site burning of aboveground biomass for:

- Conversion of forests and grasslands to agricultural land and pastures; and
- Preparation of new farms under shifting cultivation or "slash and burn" practices.

Table 31: *CH_4 Emissions From Cleared Forests and Grasslands On-Site*

Quantity of Carbon Released by Burning Cleared Aboveground Biomass (Table 3-45) (kt C)	Methane to Carbon Emission Ratio (t CH_4/t C)	Molecular Weight Ratio, 16/12	Methane Emissions from Burning of Cleared Aboveground Biomass (Gg)
2127.717	0.012	1.3333	34.043

Source:([1])

Non-carbon trace gases emissions from off-site burning of aboveground biomass are considered under the section on Energy. Table 31 shows CH_4 emissions calculations using the carbon release calculation results on Table 21. Methane emission estimates in this study, that is 34 Gg, is approximately ten times the amount estimated from burning of aboveground biomass in the previous study.

Flooding Lands

Flooding of lands due to construction of hydroelectric dams, or other activities, results in emissions of CH_4 due to anaerobic decomposition of the vegetation and soil carbon that were present when the land was flooded, as well as of organic material that grows in the floodwater, dies, and accumulates on the bottom. The CH_4 emissions from the source are highly variable and are dependent on the ecosystem type, and the status of the ecosystem, that is flooded and the depth and length of flooding. The rate of CH_4 emissions from freshwater man-made wetlands is also strongly dependent on temperature.

Land areas flooded due to man-made causes in Tanzania belong to the category of artificial impoundment mostly for hydroelectric generation and water supply. CH_4 flux calculation is be based on the area of land flooded, an average daily CH_4 emission coefficient, and the number of days in the year that the area is flooded. The following assumptions were made:

- Approximately 10 percent of the total man-made flooded area was subjected to anaerobic conditions during the wet seasons occurring annually;
- Man-made "flooded lands" (that is hydroelectric dams and water supply reservoirs) are located in "flood plains"; and

- Average daily emission rate was borrowed from the revised IPCC Revised Guidelines, which is estimated at 75 mg CH_4-C/m^2.day (equivalent to 1.0 tonne CH_4/ha.day) for 122 days.

Table 32 shows methane emissions calculation from man-made flooded lands:

Table 32: *CH_4 Emissions from Manmade Flooded Lands*

Flooded lands include hydroelectric dams and water supply reservoirs	Total Flooded to Land (kha)	Total Land Subjected Floods (kha)	Daily Methane emissions rate multiplied by 16/12 (t CH_4/ha.day)	Period of Time Flooded (days)	Total Annual Methane Emissions (Gg)
Nyumba ya Mungu	18.0	1.80	1.0	122	219.60
Mtera	61.0	6.10	1.0	122	744.20
Kidatu	15.0	1.50	1.0	122	183.00
Others (water supply reservoir)	11.3	1.13	1.0	122	137.86
Total	105.3	10.53			1284.66

Sources: ([1, 21])
Note: 75 mg CH_4-C/m^2.day is multiplied by 0.01, then by 16/12 to 1.0 t CH_4/ha.day

In previous study, a calculation error was done in converting daily CH_4 emissions rate from 32 mg CH_4-C/m^2 to 0.427 t CH_4/ha. The total amount of annual CH4 emissions was wrongly divided further by 1,000. In this study, this error was rectified, and some more changes were made by increasing the daily emission rate from 32 to 75 mg CH_4-C/m^2.day, and the period of time flooded from 90 to 122 days. Based on Table 32, the results mark man-made flooded lands as an important source of methane emissions.

Nitrous Oxide

Nitrous oxide emissions may be released by burning aboveground biomass, disturbed organic soils and flooded lands. The only source without controversy on whether the fluxes of nitrous oxide results in net emissions or removals is burning of cleared aboveground biomass. Table 33 show N_2O emissions calculation results based carbon release estimates on Table 21.

Table 33: *N_2O Emissions from Cleared Forests and Grasslands*

Quantity of Carbon Released by Burning Cleared Aboveground Biomass (Table 3-46) (kt C)	Total Nitrogen Released as calculated from Carbon Relsease multiplied by nitrogen/carbon ratio, 0.01	Nitrous oxide to Carbon Emission Ratio (t N_2O/t C)	Molecular Weight Ratio, 44/28	Carbon monoxide Emissions from Burning of Cleared Aboveground Biomass (Gg)
2127.717	21.277	0.007	1.5714	0.234

Source:([1])

In this study, nitrous oxide emissions are estimated at 0.234 Gg, about ten times the amount reported in the previous study. The reason for such significant discrepancy is mainly the refinement in the input data.

Nitrogen Oxides

NOx emissions were estimated from carbon release by burning aboveground biomass cleared for permanent agricultural land and pasture, as well as shifting cultivation practices. Unlike, CH_4 and CO emissions from burning aboveground biomass are released during the stage of smouldering, NOx and N_2O emissions are released during the flaming stage. Table 34 shows the NOx emissions calculation results.

Table 34: *NOx Emissions from Cleared Forests and Grasslands*

Quantity of Carbon Released by Burning Cleared Aboveground Biomass (Table 3-46) (kt C)	Total Nitrogen Released as calculated from Carbon Releases multiplied by nitrogen/carbon ratio, 0.01	Nitrogen oxides to Carbon Emission Ratio ($t N_2O/t C$)	Molecular Weight Ratio, 46/14	Carbon monoxide Emissions from Burning of Cleared Aboveground Biomass (Gg)
2127.717	21.277	0.121	3.8333	8.459

Source:([1])

The results on Table 34 are approximately 8.5 Gg NOx, this is ten times the amount reported during the previous study. The increase is attributed to an increase in carbon release on Table 21 compared to the amount reported in the previous study.

Carbon Monoxide

The same methodology used in calculating methane emissions applies for carbon monoxide emission estimates. The amount of carbon released by burning aboveground biomass was the basis for carbon monoxide emissions calculations. Table 35 shows the calculation procedure and the results.

Table 35: CO Emissions from Cleared Forests and Grasslands

Quantity of Carbon Released by Burning Cleared Aboveground Biomass (Table 3-46) (kt C)	Carbon monoxide to Carbon Emission Ratio (t CO/t C)	Molecular Weight Ratio, 28/12	Carbon monoxide Emissions from Burning of Cleared Aboveground Biomass (Gg)
2127.717	0.06	2.3333	297.880

Source:([1])

The calculation results on Table 35 indicate that carbon emissions estimates amounted about 298 Gg, which is about ten times the estimates, reported in previous study. Again the main source of such discrepancy is an increase in carbon release.

Non-Methane Volatile Organic Compounds (NMVOCs)

NMVOCs are produced from land use change and forest management activities, particularly where burning is involved. NMVOCs are emitted in significant quantities from burning, and these emissions can be estimated using the same approach provided for non-CO_2 gases. However, the detailed methods and default information have not yet been developed by IPCC and thence the NMVOCs emissions are not included in this study

.

Summary of GHG Emissions from Land Use Changes and Forestry

The results presented on Tables 17, 24, 27 and 30, to 35 are summarised on Table 36 for convenient reference.

Table 36: *Summary of GHG Emissions from Land Use Changes and Forestry*

Source	CO_2	CH_4	N_2O	Nox	CO	NMVOC	SO_2
Change in Forest and Woody Biomass	56176.417	NA	NA	NA	NA	NA	NA
Forest and Grassland conversion	757056.93	3290.89	22.625	817.73	28795.36	NA	NA
Abandonment of Managed Land	- 1844.150	NA	NA	NA	NA	NA	NA
CO_2 Emissions from Soils	- 935.000	NA	NA	NA	NA	NA	NA
Flooded lands	NA	1284.99	NA	NA	NA	NA	NA
Total	**816012.52**	**4575.89**	**22.63**	**817.73**	**28795.36**	**NA**	**NA**

Generally, calculation results indicated a significant increase in both non-CO_2 greenhouse gas emissions and CO_2 emissions compared to the estimates reported in the previous study. This is may be due to the refinement of both the IPCC revised methodology and activity data.

Waste

Total emissions from solid waste disposal on land, wastewater management and waste incineration are reported here. However, waste incineration technology is not practised in Tanzania. Likewise, managed waste disposal on land is not practised in Tanzania[1,11,18]. With adequate information[1, 11,12] on urban population, solid waste generation rate, waste collection and existing disposal sites, methane emissions were estimated at 17 Gg. Methane emissions from wastewater handling were estimated at 30 Gg. N_2O emissions from human sewage were estimated at 3.45 Gg. GHG emission estimates are summarised in Table 37.

Table 37: *GHG Emissions From Waste Management for 1990 (in Gg)*

Source	Type	CH_4	N_2O
Solid Waste Management	Unmanaged Solid Waste Disposal on Land	10.1993	NA
	Industrial solid waste disposal	6.4059	NA
Wastewater Handling	Domestic and Commercial Wastewater	9.8893	NA
	Industrial Wastewater	20.5887	NA
Human Sewage Management		NA	3.4528
	Total	47.0833	3.4528

Verification Report on National GHG Inventory for 1990

Prior to compiling the national greenhouse gas inventory for 1990, an independent local expert was assigned the task to verify all calculations, references, activity data and emission factors used in calculations. The local expert went through all worksheets, interviewed the researchers who made all calculations, and pointed out the areas that require further attention during finalization of National GHG Inventory for 1990.

Methods and Procedures

The local expert checked for arithmetic errors, harmonisation of units compared the national activity data to internationally published statistics by IEA, FAO and the US Country Studies Programme. With available information, it was certified that the 1990 inventory can be reproducible using the Revised 1996 IPCC Guidelines[3].

Qualities and Completeness Assessment

The quality of the revised National Greenhouse Gas Inventory for 1990 has improved. Most of activity data and assumptions are reasonable, particularly where it is impossible to acquire updated data and the emission factors, though not developed for Tanzania, but provide the better understanding of the order of magnitude. Some refinement of default emission factors may be required in future. The Overview Tables provide the summary of the quality and completeness of the inventory.

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INTRODUCTION

This inventory was compiled following the 1996 IPCC Revised Guidelines[1], using the 1994 activity data[2,3,4,5,6,7,8,9,10] the same emission factors used to compile the revised GHG inventory for 1990. The activity data were collected from relevant authorities in Tanzania, and in most cases differ from international statistics published by OECD, IEA[9] and FAO[10].

Basic Approach

The 1994 National Greenhouse Gas Inventory is organised in six main modules: energy, industrial processes, solvents and other products use, agriculture, land-use changes and forestry, and waste. In each module, efforts were made to comply with the 1996 Revised IPCC Guidelines[1] in estimating and reporting relevant GHG emissions and removals by sources or sinks.

Target Year

The activity data applied in calculations were either yearly or three year average or twenty year average data representing the actual situation in a Gregorian calendar of 1994, which starts on January 1, and ends on December 31.

Targeted Greenhouse Gases

The major direct GHG including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); and other important radioactive gases which are indirect GHG or ozone precursors including the oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) were targeted. In same cases, few gases controlled by the Montreal Protocol such as sulphur dioxide (SO_2) emissions from energy sub-sectors, as well as halocarbons (HFCs and PFCs) and sulphur hexafluoride (SF_6) emissions from industrial processes and application of solvent are reported as an additional information.

Calculating Methods

The GHG emissions and removals were calculated using Equation 1, whereas the activity data are multiplied by relevant emission factors. Most of input data obtained from published national data such as Energy Balance[2,3] for 1994, Bi-annual Review of the Tanzanian Economic Trend[11], National Sample Census of Agriculture 1993/94[8,12], and Environment Statistics in Tanzania Mainland[5]. Most of emission factors were borrowed from IPCC standard data tables except a few in agriculture and waste sectors, which were reported by CEEST[13]] in 1994 or indicated as footnotes on appropriate worksheets.

International Bunkers

CO_2 and non-CO_2 emissions estimates from international bunkers, which include international aviation and marine incoming and outgoing, were included for information only. They do not form part of the national GHG inventory. The methodology used to calculate GHG emissions from international bunkers is the same as explained above for other sources. About 353 Gg

CO_2, which is almost 12 percent of total CO_2 by the reference approach[1], is attributed to international bunkers in 1994.

CO_2 Emissions Estimates from Biomass Fuels

The final energy consumption of Tanzania in 1994, in accordance to the energy balance was dominated by biomass fuels consumption[2,3,4]. Biomass fuels in the form of woodfuel, charcoal and other non-woody biomass residues are widely used in households, cottage industries and informal sector. Due to poor rains in 1994, adverse power rationing led to increase in biomass fuel utilisation[11]. About 70,006 Gg CO_2 emissions from biomass fuels are part of closed carbon cycle, hence they do not form part of the national greenhouse gas inventory but they are used to estimate non-CO_2 emissions, which are anthropogenic emissions.

CO_2 Emission Estimates by IPCC Reference Approach

Petroleum products export, international bunkers and stock change were excluded from production and imports to establish the inventory of apparent energy consumption. Crude oil import was not disaggregated further into various refined products, hence the estimates of CO_2 emissions by IPCC reference approach provides the maximum CO_2 emissions potential of 2,921 Gg CO_2, based on carbon contents by fuel type, average carbon emission factors, fraction of carbon oxidised, and fraction carbon stored.

Estimation of GHG Emissions and Removals by Sectoral Approach

Estimation of GHG emissions and removals by the sectoral approach[1] aims at creating checks and balances of top-down and bottom-up approaches. It has also been useful in identifying those sectors and sub-sectors of priority to the nation, as far as mitigation programme is concerned. Emission factors applied in Equation 1 are much more related to the state of art of technologies employed or the best available information.

I. ENERGY SECTOR

The energy sector covers, fuel combustion in utilities and energy transformation into simpler forms, fuel combustion in manufacturing industries and constructions, transport, residential, commerce and other economic sectors, agriculture and fisheries; fugitive emissions from energy systems and coal mining. All activity data were converted from physical to energy units, from which CO_2 emissions by fuel types were estimated at 2,855 Gg CO_2. Compared to 2,921 Gg CO_2 estimated using the reference approach, the discrepancy is about 2.3% and it within the tolerable range[1] of ± 10%. The source of discrepancy is probably the difference in emission factors between disaggregated fuels data such as refined petroleum products, which are lower compared to aggregate fuel types such as crude oil, which are much higher.

a) Energy Industries

Public electricity generation, petroleum refining and charcoal making were the main three sources of GHG emissions. The activity data[2,3,4,5,13] consist of the domestic energy supply, which comprised of diesel, residue fuel oil, woodfuel, coal and lubricants. 50% of carbon in lubricants, 2% of carbon in solid fuels, and 1% of carbon in liquid fuels were considered not burning but instead turn into other chemical compounds, soot or char, and therefore were deducted from oxidized carbon. SO_2 emissions were estimated at 17 Gg, while GHG emissions from energy industries are summarized in Table 38.

Table 38: *GHG Emissions from Energy Industries for 1994 (in Gg)*

Source	CO_2	CH_4	N_2O	NOx	CO	NMVOC
Public Electricity Generation	313.9035	0.0080	0.0016	0.5307	0.0398	0.0133
Petroleum Refining	71.1896	0.0081	0.0016	0.5371	0.0403	0.0134
Charcoal Production	NA	1.7623	0.2350	5.8744	58.7432	2.9372
Total	385.0931	1.7783	0.2382	6.9422	58.8232	2.9639

b) Manufacturing Industries and Construction

Manufacturing industries in the context this inventory does not strictly follow the International Standard Industrial Classification of All Economic Activities (ISIC). In most cases, the energy consumption statistics[2,3,4,5,11,13] did not support ISIC categories. Non-CO_2 emissions were estimated from the total amount of energy consumed using default emission factors. SO_2 emissions were estimated at 28 Gg, GHG emission estimates from manufacturing industries and construction are summarized in Table 39.

Table 39: *Emissions from Manufacturing Industries and Construction for 1994 (in Gg)*

Source	CO_2	CH_4	N_2O	NOx	CO	NMVOC
Metal and Engineering	7.0008	0.0002	0.0001	0.0192	0.0010	0.0005
Non-metal and Minerals	106.2452	0.0058	0.0011	0.3027	0.0686	0.0125
Chemicals	7.1904	0.0002	0.0001	0.0215	0.0011	0.0005
Pulp, Paper and Printing	32.0919	0.0028	0.0004	0.0996	0.0406	0.0058
Food, Beverage & Tobacco	57.9192	3.1746	0.4235	10.730	221.378	5.2922
Textiles, Leather & Sisal	22.5901	0.0006	0.0002	0.0597	0.0030	0.0015
Asphalt Application on road	15.7670	0.0008	0.0002	0.0790	0.0039	0.0000
Total	248.0051	3.1850	0.4256	11.311	221.497	5.3130

c) Transport

The rate of motor vehicle import kept increasing during 1994[11,15]. The performance of civil aviation dropped[6,7,11] but railways more or less maintained the 1990 record. Equation 1 was applied as it is, using default emission factors to estimate associated GHG emissions. SO_2 emissions were estimated at 2.48 Gg, while the GHG results are summarized in Table 40.

Table 40: *GHG Emissions from Transport for 1994 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Civil Aviation	61.1200	0.0004	0.0018	0.2632	2.6125	0.0826
Road Transportation	1439.395	0.1821	0.0121	15.065	58.0456	11.0682
Railways	127.5723	0.0088	0.0011	2.1098	1.7582	0.3516
Navigation	36.2792	0.0025	0,0003	0.7423	0.4949	0.0990
Total	1664.366	0.1938	0.0152	18.181	62.9111	11.6014

Transport sector contributed 58 percent of total CO_2 emissions from the energy sector, most of it is attributed to road transport. Non-CO_2 emission estimates are relatively low compared to manufactured industries and construction, the reason being the fact that biomass fuels such as methanol or other blends are not practiced in transport sector.

d) Other Sectors

Fuel combustion in commercial and institutional sub-sector, residential sector, agriculture, forestry and fisheries was assessed and reported collectively under sub-heading "other sectors." Sulphur dioxide emissions were estimated at 126.68 Gg while the GHG emission estimates were obtained using Equation 1, and summarized in Table 41.

Table 41: *GHG Emissions from Other Sectors for 1994 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Commercial & Institutions	57.0069	8.0545	0.0962	2.9960	169.577	14.0137
Residential	436.1761	138.624	1.8213	47.405	2375.27	271.7717
Agriculture/Forestry/Fishing	63.6154	1.0228	0.0141	1.4239	17.8000	2.2084
Total	556.7983	147.701	1.9316	51.825	2552.65	287.9938

Biomass fuels are massively consumed in the commercial and residential sectors[2,3,4,5]. As a result of this, non-CO_2 emissions from commercial and residential sectors were significantly higher compared to energy industries, transport sector, and manufacturing industries.

e) Fugitive Emissions

The activity data did not change much between 1990 and 1994. The total release of methane during coal mining and post-mining activities, refining of oil and storage in tanks were estimated and summarized in Table 42. It was not possible to capture all fugitive emissions except a few. For those areas were information was not available, NA refers to "not applicable", NO refers to "not occurring", while NE refers to "not estimated."

Table 42: *Fugitive Emissions from Energy Systems for 1994 (in Gg)*

Source	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**
Coal Mining & Handling	NA	0.6052	NO	NO	NO	NE	NE
Petroleum Handling	NA	0.0718	NO	0.1389	22.8119	3.7512	1.2985
Total	NA	0.6770	NO	0.1389	22.8119	3.7512	1.2985

INDUSTRIAL PROCESSES

Industry, which accounts for nearly 15% of GDP, plays a vital role for economic development in Tanzania, mainly processing agricultural product such as sugar, beer, sisal twine, cigarettes, pulp and paper, and other light consumer goods (4).

Total emissions of all greenhouse gases from industrial process where the greenhouse gases are the by-products from transformation of raw material into intermediate of final products have been considered. The emission estimates for 1994 using the 1996 Revised IPCC Guidelines, have been reported based on available information. These are described in subsequent sections.

Cement Production

In 1994, cement output increased by 6.1% as compared to 1990 due to improved cement production. Cement manufacture is the most important source of carbon dioxide emissions from non-energy industrial processes. Carbon dioxide (CO_2) and Sulphur dioxide (SO_2) are emitted during the process of cement manufacture. Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made.

Cement produced in Tanzania is the Portland cement type, which contains 68% of lime by weight. Sulphur dioxide emissions originate from clay raw material. In 1994, CO_2 emissions from cement production were 366.18Gg, while SO_2 emissions accounted only for 0.2058Gg. Worksheets 2.3.1 and 2.3.2 summarise the emissions result for year 1994.

MODULE	**INDUSTRIAL PROCESSESS**		
SUB MODULE	**CEMENT PRODUCTION - CO_2**		
WORKSHEET	**2.3.1**		
	STEP 1		**STEP 2**
A	**B**	**C**	**D**
Quantity of Clinker or Cement Produced (t)	Emission Factors (t CO_2/t clinker or cement produced)	CO_2 Emitted (t)	CO_2 Emitted (Gg)
		C=(AxB)	D=C/10^3
686,000	0.5338	366,186.8000	366.1868

MODULE	**INDUSTRIAL PROCESSESS**		
SUB MODULE	**CEMENT PRODUCTION - SO_2**		
WORKSHEET	**2.3.2**		
	STEP 1		**STEP 2**
A	**B**	**C**	**D**
Quantity of Cement Produced (t)	Emission Factors (kg SO_2/t cement Produced)	SO_2 Emitted (kg)	SO_2 Emitted (Gg)
		C=(AxB)	D=C/10^6
686,000	0.3000	205,800.000	0.2058

Production of Lime and Limestone Use

Calcinated limestone is formed by heating at high temperatures limestone to decompose the carbonates. The mass of CO_2 produced per unit of lime may be estimated from the molecular weights and the lime content of products. Production of lime reported here is considered for pulp and paper production at the Southern Paper Mills (SPM) and has been obtained by extrapolation from paper production trends from 1992 to 1994.

CO_2 emission from lime production for pulp and paper production process in 1994 was 2.2765Gg. There has been no data readily available for limestone use other than that used in cement, pulp and paper production. Worksheet 2.4.1 summarizes the emission estimate.

MODULE	**INDUSTRIAL PROCESSESS**			
SUB MODULE	**PRODUCTION OF LIME - CO_2**			
WORKSHEET	**2.4.1**			
	STEP 1			**STEP 2**
	A	**B**	**C**	**D**
Lime Type	Quantity of Lime Produced (t)	Emission Factors (t CO_2/t quicklime or Dolomite lime	CO_2 Emitted (t)	CO_2 Emitted (Gg)
		Produced)	C=(AxB)	$D=C/10^3$
Quicklime	2,900	0.7850	2,276.5000	2.2765

Iron and Steel

To date, there is no iron production from iron ore in Tanzania. Iron and steel processing, particularly, steel rolling has been considered. NO_x and SO_2 emissions have been estimated, each to be about 0.0003 Gg, while NMVOC emissions were estimated to 0.0002 Gg. Worksheet 2.13.2B to 2.13.2E summarize the emissions results from iron and steel rolling for 1994.

MODULE	**INDUSTRIAL PROCESSESS**		
SUB MODULE	**METAL PRODUCTION - IRON AND STEEL NO_x**		
WORKSHEET	**2.13.2B**		
	STEP 1		**STEP 2**
A	**B**	**C**	**D**
Amount of Iron or Steel Produced	Emission Factors (G NO_X/t of Iron or steel produced)	NO_X Emitted (g)	NO_X Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
7,003	40.0000	280,120.0000	0.0003

MODULE	**INDUSTRIAL PROCESSESS**		
SUB MODULE	**METAL PRODUCTION - IRON AND STEEL NMVOC**		
WORKSHEET	**2.13.2C**		
	STEP 1		**STEP 2**
A	**B**	**C**	**D**
Amount of Iron or Steel Produced	Emission Factors (g NMVOC/t of Iron or steel produced)	NMVOC Emitted (g)	NMVOC Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
7,003	30.0000	210,090.0000	0.0002

MODULE	INDUSTRIAL PROCESSESS		
SUB MODULE	METAL PRODUCTION - IRON AND STEEL CO		
WORKSHEET	2.13.2D		
			STEP 2
A	B	C	D
Amount of Iron or Steel Produced	Emission Factors (g CO/t of Iron or steel produced)	CO Emitted (g)	CO Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
7,003	1.0000	7,003.0000	0.0000

SUB MODULE	METAL PRODUCTION- IRON AND STEEL SO_2		
WORKSHEET	2.13.2E		
A	B	C	D
Amount of Iron or Steel Produced	Emission Factors (g SO_2/t of Iron or steel produced)	SO_2 Emitted (g)	SO_2 Emitted (Gg)
(t)		C=(AxB)	$D=C/10^9$
7,003	45.0000	315,135.0000	0.0003

Pulp and Paper Production

The Southern Paper Mills Company Limited is a fully integrated pulp and paper mill. In 1994 paper production dropped significantly, where 10,270 tonnes of paper were produced as compared to 23,332 tonnes in 1990 (7). The major sources of greenhouse gas emissions at the mills include: the power boiler, calcination of limestone to produce lime, and recovery process. The emission estimates are based on total annual production of dried pulp.

Emission from lime production from the calcination of limestone process is reported under Lime Production. NO_x, CO, SO_2 and NMVOC emissions from pulp and paper production were 0.0154Gg, 0.0575Gg, 0.0719Gg and 0.038Gg, respectively. Worksheets 2.14.1A to 2.14.1D summarize the emissions levels for 1994 from pulp and paper production process.

MODULE	INDUSTRIAL PROCESSESS			
SUB MODULE	Pulp and Paper Industries - NO_x			
WORKSHEET	2.14.1A			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg NO_x/t Air dried pulp produced)	NO_x Emitted	NO_x Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	10,270	1.5000	15,405.0000	0.0154

MODULE	INDUSTRIAL PROCESSESS			
SUB MODULE	Pulp and Paper Industries - NMVOC			
WORKSHEET	2.14.1B			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg NMVOC/t Air dried pulp produced)	NMVOC Emitted	NMVOC Emitted
			(kg)	(Gg)
	(t)		C=(AxB)	$D=C/10^6$
Kraft	10,270	3.7000	37,999.0000	0.0380

MODULE	INDUSTRIAL PROCESSESS			
SUB MODULE	Pulp and Paper Industries - CO			
WORKSHEET	2.14.1C			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg CO/t Air dried pulp produced)	CO Emitted	CO Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	10,270	5.6000	57,512.0000	0.0575

MODULE	INDUSTRIAL PROCESSESS			
SUB MODULE	Pulp and Paper Industries - SO_2			
WORKSHEET	2.14.1D			
		STEP 1		STEP 2
	A	B	C	D
Pulp Process Type	Quantity of Air Dried Pulp Produced	Emission Factors (kg SO_2/t Air dried pulp produced)	SO_2 Emitted	SO_2 Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
Kraft	10,270	7.0000	71,890.0000	0.0719

Food and Drink Production

Alcoholic beverage, and bread and other food production processes contribute to greenhouse gas emissions. In 1994, there was an improve in the production of beer and spirits, while wine production decreased. During this period there was no beef production due to closure of the beef canning plant. NMVOC emission estimates from beer, wine, spirits, biscuits, sugar, margarine and solid cooking fats, coffee roasting and animal feed production, have been considered where information is available. NMVOC emissions for 1994 were estimated to 1.2579Gg from bread and other food production category, and 0.3149Gg from alcoholic beverage production. Worksheets 2.15.1 and 2.15.2 summarize emission estimates from alcoholic beverage and bread and other food production respectively.

MODULE	**INDUSTRIAL PROCESSESS**			
SUB MODULE	**ALCOHOLIC BEVERAGE PRODUCTION - NMVOC**			
WORKSHEET	**2.15.1**			
				STEP 2
	A	**B**	**C**	**D**
Alcoholic Beverage type	Quantity of Alcoholic Beverage Produced	Emission Factors (kg NMVOC/ hL beverage produced)	NMVOC Emitted (kg)	NMVOC Emitted (Gg)
	(hL)		C=(AxB)	D=C/10^6
Spirits (Konyagi)	19,660	15.0000	294,900.0000	0.2949
Beer	568,420	0.0350	19,894.7000	0.0199
Wine	1,690	0.0800	135.2000	0.0001
TOTAL				**0.3149**

MODULE	**INDUSTRIAL PROCESSESS**			
SUB MODULE	**BREAD AND OTHER FOOD PRODUCTION -NMVOC**			
WORKSHEET	**2.15.2**			
	STEP 1			**STEP 2**
	A	**B**	**C**	**D**
Food Production Type	Quantity of Food Produced	Emission Factors (kg NMVOC/ t Food produced)	NMVOC Emitted	NMVOC Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	D=C/10^6
Biscuits	241	1.000	241.000	0.0002
Sugar	112,000	10.0000	1,120,000.000	1.1200
Margarine & Solid cooking fats	11,477	10.0000	114,770.000	0.1148
Coffee roasting	38,618	0.5500	21,239.900	0.0212
Animal feed	1,695	1.0000	1,695.000	0.0017
TOTAL				**1.2579**

Glassware Production

NMVOC emissions from glassware production have been considered. NMVOC emissions are estimated to 0.034Gg in 1994. Worksheet 2.7.2B summarize the emission estimates.

MODULE	INDUSTRIAL PROCESSESS			
SUB MODULE	MANUFACTURE OF OTHER MINERAL PRODUCTS - GLASS - NMVOC			
WORKSHEET	2.7.2B			
	STEP 1			
	A	B	C	D
Glass Type	Quantity of Glass Produced	Emission Factors (kg NMVOC/t glass produced)	NMVOC Emitted	NMVOC Emitted
	(t)		(kg)	(Gg)
			C=(AxB)	$D=C/10^6$
			-	-
Glassware	7,553	4.5000	3,988.5000	0.0340

Natural Carbon Dioxide Reserves

Tanzania has underground CO_2 and other gases emission at Kyejo in Mbeya region. The emission at Kyejo is a natural process and the gas emitted is composed of 80% CO_2 and 20% other gases.

In recent years, it has been exploited significantly, and the emission is now considered to be man-made. Emission estimates is based on the CO_2 produced. In 1994, about 2.0014 Gg of CO_2 were produced. This shows an increase of about 37% as compared to 1990.

Emissions From CFCs and Other Greenhouse Gases

Tanzania does not produce ODS. The consumption estimates reported are based on imports figures and others statistics form different sources. The overall demand forecast for controlled substances is largely influenced by a range of macro economic factors, including growth rate of Gross Domestic Product (GDP), population, and new investments in ODS user sectors. Table 43 shows the consumption of ODS by categories in 1994, which depict the potential emissions from the CFCs.

Table 43: *Potential Emissions of ODS by Sectors and Categories in 1994*

Sector	Substance	Consumption (Tonnes)	Ozone Depleting Potential (ODP)	Potential Emissions (ODP Tonnes)
Aerosols	CFC-11	75.00	1	75.00
	CFC-12	75.00	1	75.00
Refrigeration & Air Conditioning	CFC-11	30.00	1	30.00
	CFC-12	55.50	1	55.50
	CFC-115	0.60	0.6	0.36
Foams	CFC-11	27.00	1	27.00
Cleaning	Carbon tetrachloride	0.90	1.1	1.0
Fire Fighting	Halon-1301	0.05	10	0.50

Source (2)

Currently, there is no readily available data on HFCs, PFCs, and SF_6 use, which are serving as alternatives to ozone depleting substances (ODS). CFCs usage in the sectors of aerosols, refrigeration and air conditioning, and foams manufacturing will continue to grow steadily up to the year 2010 as projected in Figure 1. Based on the current pattern of ODS use, the use of these substances is currently insignificant. However, with the rapid growth of many cities in Tanzania and the gradual inceasing in economic activities, HFCs, PFCs, and SF_6 could be important contributors of greenhouse gas emissions in the future because of their expected extensive use in refrigeration, air conditioning, fire extinguishing, aerosols, solvents and foam production.

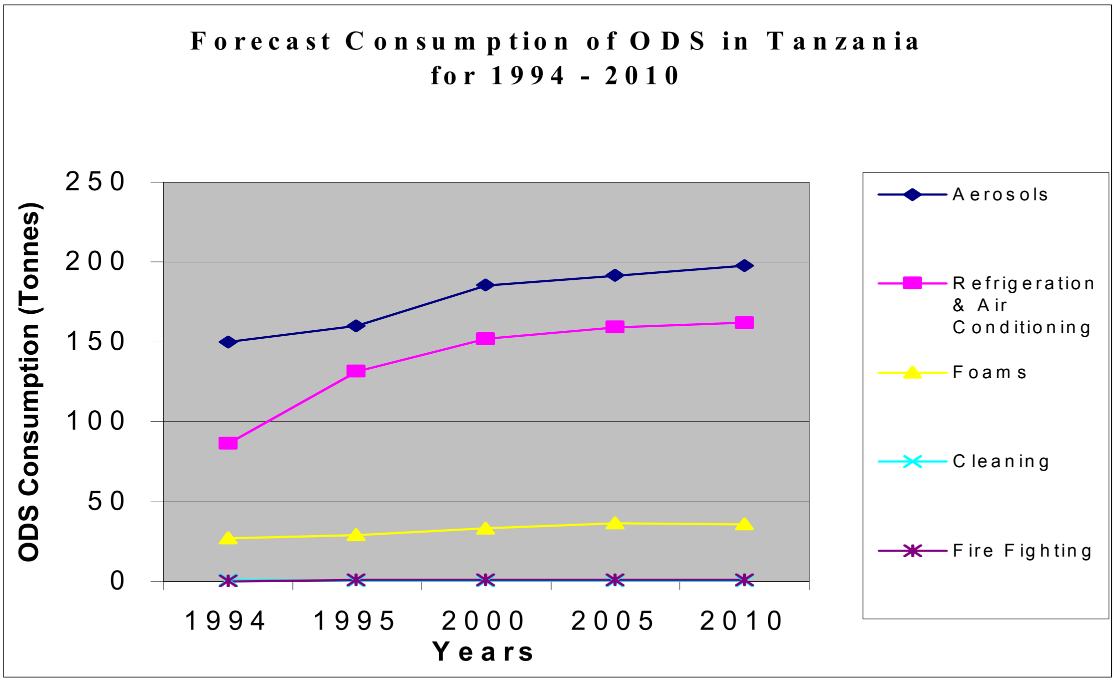

Figure 2

Following the application of the revised 1996 IPCC Guidelines, emissions from other source categories which were not reported in 1990 have been considered for year 1994, only where data is available. In general, a lot of data gaps in various industrial processes and solvents and other products use do exist.

During the preparation of emissions estmates, it has been difficult to get sufficient data from industries for that purpose. Most of the industries do not have a proper way of keeping data and information. They keep data and information the way they think is appropriate for them in conducting their business, reporting for taxation, and annual returns purposes.

In order to improve the reporting quality, there is a need of designing a way for which there should be a co-ordinated effort that will ensure that relevant data and information on various industrial processes is retrieved and updated from time to time. Further, industrialists should be educated on the importance of having an inventory of GHGs, which is updated regularly and how the production processes relate to GHGs, which cause climate change. In this respect they will learn, improve and maintain high data quality to facilitate improved quality of greenhouse gas emissions inventory in the future.

The major source category in industrial processes for 1994 continued to be Mineral Production, mainly from cement production process. The total CO_2 emission from industrial processes in 1994 is estimated to 370.4647Gg as compared to 352.9Gg in 1990. The estimate shows an increase of emissions by 4.7%. NMVOC emissions are estimated to 1.6451Gg while in 1990 was estimated to 1.5851Gg, showing an increase by 3.6%. NO_x, CO, and SO_2 showed to decrease. While SO_2 decreased from 0.357Gg in 1990 to 0.278Gg in 1994, NO_x decreased from 0.0354Gg to 0.0157Gg and CO decreased from 0.1307Gg to 0.0575Gg, respectively.

Based on little data and information available, Table 44 (Worksheet 1 and 2) summarizes the total emissions from various industrial processes for 1994.

TABLE 2 SECTORAL REPORT FOR INDUSTRIAL PROCESSES (Sheet 1 of 2)											
			SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES								
					(Gg)						
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOC**	**SO_2**	**HFC**		**PFCs**	
(TOTAL SHEET 1 AND 2)	**370.4647**	**0.0000**	**0.0000**	**0.0157**	**0.0575**	**1.6451**	**0.2780**	**P**	**A**	**P**	A
Total Industrial Processes	**368.4633**	**0.0000**	**0.0000**	**0.0003**	**0.0000**	**0.0002**	**0.2061**	NE		NE	
A Mineral Production	***368.4633***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.2058***				
1 Cement Production	366.1868						0.2058				
2 Lime Production	2.2765										
3 Limestone and Dolomite Use	0.0000										
4 Soda Ash Production and Use											
5 Asphalt Roofing											
6 Road Paving with Asphalt											
7 Other											
B Chemical Industry	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***				
1 Ammonia Production											
2 Nitric Acid Production											
3 Adipic Acid Production											
4 Carbide Production											
5 Other											
C Metal Production	***0.0000***	***0.0000***	***0.0000***	***0.0003***	***0.0000***	***0.0002***	***0.0003***				
1 Iron and Steel Production											
2 Ferroalloys Producion											
3 Aluminium Production											
4 SF6 Used in Aluminium and Magnesium Foundaries											
5 Other (Iron and Steel Rolling)				0.0003	0.0000	0.0002	0.0003				

P=Potential emissions based on Tier 1 Approach. A=Actual emissions based on Tier 2 Approach.

TABLE 2 SECTORAL REPORT FOR INDUSTRIAL PROCESSES (Sheet 2 of 2)											
			SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES								
					(Gg)						
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**CO_2**	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOC**	**SO_2**	**HFC**		**PFCs**	
								P	**A**	**P**	**A**
Total Industrial Processes	**2.0014**	**0.0000**	**0.0000**	**0.0154**	**0.0575**	**1.6449**	**0.0719**	NE		NE	
D Other Production	***0.0000***	***0.0000***	***0.0000***	***0.0154***	***0.0575***	***1.6449***	***0.0719***				
1 Pulp and Paper				0.0154	0.0575	0.0380	0.0719				
2 Food and Drink						1.5729					
3 Glassware						0.0340					
E Production of Halocarbons and Sulphur Hexafluoride	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***				
1 By-product Emissions											
2 Fugitive Emissions											
3 Other											
F Consumption of Halocarbons and Sulphur Hexafluoride	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***				
1 Refrigeration and Air Conditioning Equipment											
2 Foam Blowing											
3 Fire Extinguishers											
4 Aerosols											
5 Solvents											
6 Other											
G Other(Natural occuring Carbon dioxide)	***2.0014***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***				

P=Potential emissions based on Tier 1 Approach. A=Actual emissions based on Tier 2 Approach.

II. AGRICULTURE

Tanzanian economy had decelerated[11] from a peak of 6.3% (real growth of GDP at 1992 prices) in 1990 to only 0.8% in 1993, and 1.6% in 1994. Food crops production declined mainly due to poor rains and inadequate use of chemical fertilizers, which into larger extent was a result of higher prices of the chemical fertilizers[5,11,16]. This inventory covers GHG emissions from livestock, rice cultivation, agricultural soils, prescribed burning of savannah, and field burning of agricultural residues.

a) Enteric Fermentation

With exception of sheep, a number other livestock increased[8] from the activity data that was reported for 1990. As a result methane emissions in 1994 increased. The 1994 survey data and emission factors generated using Tier 1 approach[1] were used to estimate methane from enteric fermentation. However, the calculation approach remained the same for both inventories. The results of CH_4 emission estimates are summarized in Table 45.

Table 45: *GHG Emissions from Enteric Fermentation for 1994*

Livestock Type	Number of Animals	Emission Factor	Methane Emissions
	(thousands)	(kg/head/year)	(Gg)
Dairy Cattle	157.472	84.851	13.3616
Non-Dairy Cattle	13,502.349	40.887	552.0705
Sheep	2,692.716	0.185	0.4982
Goats	8,641.221	0.195	1.6850
Mules and Asses	277.427	1.045	0.2899
Swine	327.000	1.000	0.3270
Poultry	21,500.083	NA	NA
		Total	568.2322

b) Manure Management

Methane and nitrous oxide from animal manure management occurs as the result of its decomposition under anaerobic conditions. Methane emissions from animal manure handling were calculated and summarized in Table 46.

Table 46: *CH_4 Emissions from Animal Manure Handling for 19*94

Livestock Type	Number of Animals	Emission Factor	Methane Emissions
	(thousands)	(kg/head/year)	(Gg)
Dairy Cattle	157.472	1.000	0.1575
Non-Dairy Cattle	13,502.349	1.000	13.5023
Sheep	2,692.716	0.210	0.5655
Goats	8,641.221	0.220	1.9011
Mules and Asses	277.427	1.190	0.3301
Swine	327.000	2.000	0.6540
Poultry	21,500.083	0.023	0.4945
		Total	17.6050

The number of animals increased considerably[8,14] between 1990 and 1994. As a result, N_2O emissions from animal waste management systems such as liquid systems and storage of animal waste in heaps of drylots for more than one month increased to about 0.7 Gg. N_2O emission estimates were calculated and summarised in Table 47.

Table 47: *N_2O Emissions from Animal Manure Management for 199***4**

Manure Management	Nitrogen Excretion (kg N/year)	Emission Factor (kg N_2O-N/ kg N)	N_2O Emissions (Gg)
	A	B	C=(AxB) x 44/28 x 10^{-6}
Liquid Systems	366,240	0.001	0.0006
Solid Storage and Drylots	22,470,815	0.020	0.7062
		Total	0.7068

c) Rice Cultivation

With the exception of drought prone areas, all other areas under rice cultivation in 1994 were increased. As a result methane emissions from paddy rice increased by 20 percent from 1990 levels[10]. The anaerobic decomposition of organic material in paddy rice fields produced methane, which escaped to the atmosphere by bubbling up through water column, diffused across the water/air interface, and transported through the rice plants. Methane emission estimates from rice cultivation for 1994 are summarized in Table 48.

Table 48: *Methane Emissions From Rice Cultivation for 1994*

Water Control	**Aeration**	**Area**	**Scaling Factor**	**Correction Factor**	**Emission Factor**	**CH_4 Emissions**
		(m^2 x 10^{-9})				(Gg)
Continuous Flooded		0.133	1.0	1.0	20	2.650
Intermittently Flooded	Single	0.155	0.5	1.0	20	1.550
	Multiple	0.048	0.2	1.0	20	0.192
Flooded Prone		3.063	0.8	2.0	20	98.000
Drought Prone		0.132	0.4	1.0	20	1.056
	Total	3.530				103.448

Agricultural Soils

Leaching from animal manure increases from the increase in number of livestock. The use of synthetic fertilisers decreased[5,11,16]. No changes was made to area estimated to be under histosol[14] in 1994 compared to the area covered in 1994. Further work will be required to ensure that the methodology and activity data are transparent and easily reproducible. The GHG emission estimates from agricultural soils are summarised in Table 49.

Table 49: *N_2O Emissions From Agricultural Soils for 1994*

Category	**Source**	**N_2O Emissions (Gg)**
Direct Emissions	Application of Synthetic Fertilisers, Nitrogen Fixing Bacteria, Animal Manure, and Compost	5.3271
Indirect Emissions	Leaching of Synthetic Fertilisers and Animal Manure	31.7352
	Total	37.0623

e) Prescribed Burning of Savannah

No change was made to the area of prescribed burning of Savannahs in 1994[1]. As a result, GHG emission estimates for 1994 remained the same as the estimates for 1990. Estimating the area burned and establishing the right emission factors that are representative of East Africa including Mozambique, Malawi, Zambia, Burundi and Rwanda are yet the challenge, that need to be overcome based on experience gained in West Africa and Latin America. The GHG emission estimates from prescribed burning of savannah are summarised in Table 50.

Table 50: *GHG Emissions From Prescribed Burning of Savannah for 1994 (in Gg)*

Type of Savannah	**Burned Area (kha)**	**CH_4**	**N_2O**	**NOx**	**CO**
Humid	7,800	82.6316	1.0225	36.9584	2169.0789
Semi-Arid	4,200	32.5413	0.4027	14.5547	854.2082
	12.000	115.1728	1.4253	51.5131	3023.2871

e) Field Burning of Agricultural Residues

Field burning of agricultural residues in this inventory focuses cotton stalks, rice husks and sugarcane leaves. The activity data were estimated from crop production[11,13], which seem to increase in the case of cotton, and drop in the case of rice and cane sugar. The emission factors were developed by the local experts and reported in 1994. The non-CO_2 GHG emission estimates are summarised in Table 51.

Table 51: *GHG Emissions From Field Burning of Agricultural Residues for 1994 (in Gg)*

Source	**CH_4**	**N_2O**	**NOx**	**CO**
Rice Husks	1.6011	0.0396	1.4322	33.6233
Sugarcane Leaves	0.0191	0.0005	0.0170	0.4002
Cotton Stalks	22.3146	0.5523	19.9612	468.6066
	23.9348	0.5924	21.4105	502.6300

III: LAND-USE CHANGES AND FORESTRY

This section covers estimation of emission of Greenhouse gases from land-use and forestry sector in Tanzania (Table 52). Important categories of land-use change activities that contribute to emission of greenhouse gases, which have been considered, include:

- Changes in forest and other woody biomass stocks, which includes commercial management, harvest of industrial round-wood (logs) and fuel-wood, production and use of wood commodities, and establishment and operation of forest plantations as well as planting trees in urban and village areas;
- Forest and grassland conversion to pastures, cropland, or other managed uses, which can significantly change carbon stored in vegetation and soil;
- Abandonment of croplands, pastures, plantation forests, or other managed lands which re-grow into their prior natural grassland or forest conditions; and
- Change in soil carbon following any new forest management or agricultural practice.

Table 52: *GHG Emission from Land-Use Changes and Forestry*

Source	**CO_2**	**CH_4**	**N_2O**	**Nox**	**CO**	**NMVOC**	**SO_2**
Change in Forest and Woody Biomass	56176.41	NA	NA	NA	NA	NA	NA
Forest and Grassland conversion	757056.9	3290.89	22.63	817.73	28795.36	NA	NA
Abandonment of Managed Land	-1844.15	NA	NA	NA	NA	NA	NA
CO_2 Emissions from Soils	- 935.00	NA	NA	NA	NA	NA	NA
Flooded lands	NA	1284.99	NA	NA	NA	NA	NA
Total	**816012.5**	**4575.89**	**22.63**	**817.73**	**28795.36**	**NA**	**NA**

It should be noted that no changes were observed between the inventory for 1990 and 1994, this is because no new input of activity data was developed. This is due to the fact that no current forest inventory was carried out and no any new forest policy or intervention was done, therefore, in the interval of four years one should not expect significant changes in forest coverage. Generally, all the calculation results for both non-CO_2 greenhouse gas emissions and CO_2 emissions that were estimated by the use IPCC revised methodology for 1990 remained the same.

IV: WASTE

The urban population in 1994 is estimated to have increased from 5.37 million in 1990 to about 6.02 million in 1994 but the performance in collection of waste dropped a little[15,17,18]. As a result the total emissions from solid waste disposal on land, wastewater management remained almost the same. With adequate information on solid waste collection and existing disposal sites, methane emissions for 1994 were estimated at 16.6 Gg. Methane emissions from wastewater handling were estimated at 31.7 Gg. N_2O emissions from human sewage were estimated at 3.98 Gg. GHG emission estimates are summarised in Table 53.

Table 53: *GHG Emissions from Waste Management for 1994 (in Gg)*

Source	Type	CH_4	N_2O
Solid Waste Management	Unmanaged Solid Waste Disposal on Land	10.7577	NA
	Industrial solid waste disposal	5.8520	NA
Wastewater Handling	Domestic and Commercial Wastewater	11.1076	NA
	Industrial Wastewater	20.5887	NA
Human Sewage Management		NA	3.9776
	Total	48.3060	3.9776

Verification Report on National GHG Inventory for 1994

Prior to compiling the national greenhouse gas inventory for 1994, an independent local expert was assigned the task to verify all calculations, references, activity data and emission factors used in calculations. The local expert went through all worksheets, interviewed the researchers who made all calculations, and pointed out the areas that require further attention during finalization of National GHG Inventory for 1994.

Methods and Procedures

The local expert checked for arithmetic errors, harmonisation of units compared to the national activity data to internationally published statistics by IEA, FAO and US Country Studies Program. With available information, it was certified that the 1994 inventory could be reproducible using the Revised 1996 IPCC Guidelines.

Quality and Completeness Assessment

The quality of the revised National Greenhouse Gas Inventory for 1994 has improved. Most of activity data and assumptions are reasonable, particularly where it is impossible to acquire updated data and the emission factors, though not developed for Tanzania, but provide a better understanding of the order of magnitude. Some refinement of default emission factors may be required in future. The Overview Tables provide the summary of the quality and completeness of the inventory.

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