Climate Change Mitigation in Southern Africa

Tanzania Country Study

CEEST
The Centre for Energy, Environment, Science and Technology

Ministry of Energy and Minerals, Tanzania

UNEP

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CLIMATE CHANGE MITIGATION IN SOUTHERN AFRICA

TANZANIA COUNTRY STUDY

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Foreword

This report on a climate change mitigation study of Tanzania is one of a set of three country studies carried out under the Danida project "Climate Change Mitigation in Southern Africa: Phase 2". The project was initiated in 1996 in parallel with the UNEP/GEF project "Economics of Greenhouse Gas Limitations". Both projects were coordinated by the UNEP Collaborating Centre at Risø National Laboratory.

The limitation of greenhouse gas (GHG) emissions is a complex issue, intimately connected with economic development at local, national, regional and global levels. Key economic sectors such as energy, agriculture, industry and forestry all produce GHGs, and are likely to be affected directly and indirectly by any mitigation policy. The UNEP Greenhouse Gas Abatement Costing Studies, initiated in 1991 and coordinated by the UNEP Collaborating Centre at Risø National Laboratory, attempted to address these complex issues, developing a methodological framework and testing it through practical application in ten countries. The results of Phase Two were published in 1994 and a third phase, extending the approach to other gases and sectors, and applying it in two countries, was completed at the end of 1995.

In 1996 the UNEP Centre launched a project entitled "Economics of GHG Limitations" comprising eight national and two regional studies in parallel with a methodological development programme. The project was financed by the Global Environment Facility (GEF) through UNEP, and the UNEP Centre was responsible for coordination of the individual studies as well as development of the methodological framework, working in close collaboration with Lawrence Berkeley National Laboratory (LBNL). The national and regional studies were carried out by centres and government agencies in the participating countries and regions. Participating countries were Argentina, Ecuador, Estonia, Hungary, Indonesia, Mauritius, Senegal and Vietnam. The two sub-regional studies focus on the SADC (Southern African Development Community) countries in southern Africa and the Andean Group countries in South America.

In parallel with this UNEP/GEF project a number of other country studies were initiated. These comprise Botswana, Tanzania and Zambia in Southern Africa (financed by Danida), Peru (also financed by Danida) and Egypt and Jordan (financed by GEF through UNDP). Thus a total of fourteen countries, spanning the three "developing" continents, Africa, Asia and Latin America, and also including former centrally planned countries, are following a common set of assumptions and methodological guidelines, over the same time schedule, with coordinated project management and support from the UNEP Centre and LBNL.

The fourteen countries represent a wide mix of systems with respect to energy and other sectors, and in terms of level of development, rural/urban mix, availability of natural resources, etc. This diversity facilitates the broad development of methodological guidelines to treat a variety of circumstances and settings. In particular, the broadening of the analysis from simply energy, as in the early phases of mitigation studies, to treat forestry, land-use and agriculture introduces significant challenges. The Methodological Guidelines followed by the country teams are generally an extension of those developed in the UNEP GHG Abatement

Costing Study. These have been enhanced and extended with respect to forestry and land-use mitigation options, macroeconomic assessment and multi-criteria assessment.

The Tanzania country study was carried out on behalf of the Ministry of Energy and Minerals, Tanzania by the Centre for Energy, Environment, Science and Technology (CEEST), Dar es Salaam, under the direction of Professor Mark M. Mwandosya. The main author of the work was Mr Hubert Meena of CEEST. The work is a continuation of a preliminary study (Phase 1) carried out by the UNEP Centre and the Centres and Ministries in the region. This first phase was instrumental in establishing the background for the detailed mitigation studies of the three countries, Botswana, Tanzania and Zambia, as well as for initiating the regional study of the SADC countries which was carried out as a part of the UNEP/GEF project "Economics of GHG Limitations". In the case of Tanzania, the present study also follows on from a mitigation study focussed on the energy sector and financed by German (GTZ) assistance with technical backstopping by the UNEP Centre.

The UNEP Centre wishes to acknowledge the productive cooperation and support provided by the Ministry of Energy and Minerals, Tanzania in the execution of this study.

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Financial support for this study was generously provided by the Danish International Development Agency (DANIDA) and the UNEP Collaborating Centre on Energy and Environment (UCCEE) at Risø National Laboratory, being support by the Danish Government to the Government of the United Republic of Tanzania to enable the latter meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). We recognise Dr. John Christensen, the head of UCCEE who made this cooperation possible and Dr. Gordon Mackenzie who was the responsible programme officer from the UNEP Collaborating Centre on Energy and Environment. His cooperation during the implementation of this project was crucial to the success of the study. We also recognise the Lawrence Berkeley National Laboratory, for hosting a CEEST researcher for two weeks while finalising the report. Dr. Willy Makundi was the responsible person for providing technical guidance and backstopping services especially on the use of Comprehensive Forestry Mitigation Analysis Process (COMAP) model.

The results of this study underwent a peer review process by Tanzanian and external experts. CEEST wishes to recognise Prof. S. Lwakabamba, Dr. Gordon Mackenzie, Mr. Mac Callaway and Dr. Willy Makundi for reviewing various drafts of the report. Furthermore, we recognise the contribution of various members of the UCCEE during the various training and capacity building workshops who in one way or another contributed to the successful completion of the study. Just to mention a few, we recognise Dr. Kirsten Halsnæs, Mr. Henrik Meyer, Dr. John Turkson, Mr. Arturo Villavicencio and Mr. Jørgen Fenhann. We also commend collaboration from the Southern Centre for Energy and Environment, Zimbabwe, particularly Dr. S. Maya and Mr. Norbert Nziramasanga.

This collaborative work is an illustration that Tanzania and indeed other developing countries recognise the fact that climate change is global in nature and the response to it requires cooperation and participation by all countries in accordance with their common but differentiated responsibilities and respective capabilities.

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EXECUTIVE SUMMARY

1 Introduction

Objectives of this study are to analyse the role of the land use sectors of Tanzania (especially forestry) on mitigation of greenhouse gases. Specific emphasis is placed on the relationship between forestry and energy supply from biomass, as well as other forestry products. This is a follow up study on an earlier effort which worked on mitigation options in the country without an in-depth analysis of the forestry and land use sectors. Analysis of the mitigation scenario has been based on Comprehensive Mitigation Analysis (COMAP).

2 Review of Previous Climate Change Studies in Tanzania

Various climate change studies have been undertaken in Tanzania. The major ones include a study on Sources and Sinks of Greenhouse Gases in Tanzania; Technological and Other Options for the Mitigation of Greenhouse Gases in Tanzania; and Assessment of Vulnerability and Adaptation to Climate Change Impacts in Tanzania.

2.1 Inventories of Greenhouse Gas Emission

The study on sources and sinks of greenhouse gases (GHG) was undertaken in 1993, with the objective of establishing an inventory of sources of emissions and removal by sinks of GHGs in Tanzania. The results of the study showed that carbon dioxide emissions from Tanzania in 1990 amounted to 55,208 Gg CO_2. Total emissions, evaluation with the Global Warming Potential Index (GWP) indicates that the emissions of CO_2 contributed 55% to potential warming due to the 1990 emissions, CH_4 provided 44%, and N_2O provided 1% (Figure 1).

Land-use changes and forestry sector made the largest contribution (53%) towards the warming that may result from the 1990 emissions of trace gas in Tanzania followed by agriculture (33%), energy (13%), and waste management (1%). Industrial processes contributed less than 1% of potential warming

2.2 Greenhouse Gas Mitigation

The examination of the long-term macroeconomic scenario was on the basis of Cross-Impact Matrix method. The analysis starts by establishing a list of pertinent elements, which make up the building blocks of the scenarios. This led to identification of the most likely scenario for the long-term development of Tanzania, which is 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 sector by sector assessment identified various mitigation options which included, among others, the applications of efficiency technologies in energy production and use, efficient technologies for cement, pulp, and paper production, fuel switch in transport sector, transport management and optimisation in transport modes. Others included efficiency in rice cultivation, better animal feed practices, afforestation, forest management, and urban tree planting.

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.

2.3 Vulnerability and Adaptation Assessment

The vulnerability and adaptation assessment involved the development of climate change scenarios; assessment of impacts of climate change on water resources; and impact of sea level rise on coastline. Others areas assessed included the grassland/livestock impacts and adaptation assessment; potential impacts of climate change on coffee, cotton and maize crops production; impacts of climate change on forest resources and climate change impacts on malaria disease.

2.4 National Action Plan on Climate Change

The national action plan development involved the assessment of the national planning process and its relevance in development of the climate change action plan. Sectoral assessment included the energy, industry, transport, water resources, agriculture, and coastal resources. Barriers to implementation and methods for overcoming them were also studied.

3 Overview of the Forestry and Land-use Sector

Tanzania comprises a wide range of vegetation types, including closed forests, mangrove forests, many types of woodlands, grasslands, swamps and bogs, cultivated land and active induced vegetation and areas of semi desert. Distribution of the vegetation cover is as follows: about 50% of the total land area is forest and woodlands, 40% is grasslands and shrubs and 6 to 8 percent is cultivated land.

Deforestation in the context of Tanzania involves harvesting forest products and clear felling for settlement purposes or agriculture. Clearing of forests for woodfuel has also been considered.

4 The Energy Situation and its Relationship to Forestry

Tanzania, Like most developing countries in which woodlands and wooden grasslands are the predominant type of vegetation, biomass, particularly woodfuel (charcoal and firewood), is the main source of energy to both rural and urban areas. It accounts for approximately more than 90% of the primary energy supply. Commercial energy sources, i.e., petroleum and electricity, account for about 8% and 1% respectively of the primary energy used. Coal accounts for less than 1% of the energy used. Total annual fuelwood and charcoal use is estimated at 32 million cubic metres of which only 1/3 is obtained from clearing the forests for charcoal and fuelwood. The rest is obtained from agricultural clearing.

5 Assumptions for the Scenarios and Policies Relevant to the Land-use Sectors

The following assumption has been made: that deforestation has three agents working at the same time, tree regrowth will not recover the original biomass in a short time, unless the area is left fallow for a long time. Furthermore, the activities are related, whereby logging removes the big trees and then charcoal making uses the remaining branches and agriculture clears the rest. Remains from agricultural clearing are either burnt on site or taken away as fuelwood while other decay on site. On the basis of the aforesaid, three scenarios were developed, including the catastrophic scenario, the enhanced TFAP scenario and the Mitigation Scenario.

The existing policies and legislation have an implication in the current forestry status as well as to the success of any mitigation options. The relevant policies here include the land tenure and Land policy and legislation, forestry policy and legislation, environmental policy and legislation, population policy, and the national energy policy.

6 The Catastrophic Scenario

In greenhouse gas mitigation analysis, it has always been assumed that the baseline scenarios are consistent with national plans and programmes. However, in forest and land use sectors policies and programmes do exist, which forms the baseline, but due to various problems, they are not implemented. Therefore, in our analysis instead of having two path, the baseline situation and mitigation situation, there is a situation whereby the baseline path is not implemented. This path is hereby named the “catastrophic” scenario, which is an inconsistent one and a business as usual trend is experienced. Under this scenario it is assumed that programmes in the forestry and land use sectors envisaged in the relevant policies are not implemented or are implemented in pieces. This may be due to various problems encountering the country including the following:-

- lack of financial resources to implement the programmes;
- lack of awareness on the part of stakeholders;
- incompatibility of other sector policies and programmes which relate to forestry and land use;
- less priority accorded by policy makers;

6.1 Characteristics of the Catastrophic Scenario

Forests, which are accessible to human activities, will suffer severely under the catastrophic scenario. Therefore, the tropical closed forests and mangrove forests, which in most cases in Tanzania are located within reach of neighbouring inhabitant, are in a danger of being depleted. The miombo woodlands have an advantage of a big part of it being inaccessible.

The following assumptions for the catastrophic scenario were made:-

- Deforestation and emissions due to agriculture will continue to be influenced by population pressure and therefore its growth will be 2.8%;
- Deforestation and associated emissions due to other economic activities like timber and poles will be influenced by economic growth and therefore will grow at 5%;
- Inaccessible forests continues to operate the closed carbon cycle and therefore are not considered here; and
- CO_2 emissions and sequestration is therefore associated with dynamic activities of tree cutting/harvesting and regrowth/planting.

Under the catastrophic scenario net CO_2 emissions almost trebles, mainly due to extensive land clearing for agriculture and unsustainable harvesting of forests, which shrinks the sinks to less than one fifth. The situation is expected to worsen due to the fact that out of every 20 hectares of forests, which are clearfelled, only one hectare is planted.

7 The ‘Enhanced TFAP’ Scenario

The enhanced TFAP scenario development is based on the existing national development plans including the Tanzania Forestry Action Plan (TFAP) and projections based on Forest Management Plans. Since TFAP target is the year 2008, implementation beyond the year 2008 is extrapolated on the basis of these programmes and projects. The programmes in the enhanced TFAP included: land husbandry; forest industries; forest management; and bioenergy.

Land husbandry involves all activities related to sustainable utilisation of the land for various uses. These include agroforestry, maintenance of catchment forests, and sustainable woodfuel harvesting. Under village forestry programmes activities include afforestation, agroforestry and community forest for fuelwood.

As for forest industries, the TFAP target is to ensure solution to the various problems in the forestry sector through the following:

- utilization of wood resources with less waste;
- where applicable, substitution of hardwood by softwood;
- more emphasis to be given to utilisation of lesser-known hardwood species; and

- utilization of surplus softwood through new investment in industry capacity.

Forest management programmes include protection and rehabilitation of the existing forests, as well as controlling them in the form of sustainable harvesting. Projects under this programme include gazetting of new forest reserves, management of the miombo forests, hardwood plantation in closed broadleaf forests and management of plantation forests including the Sao hill softwood forest. This programme is expected to cost US$ 33.33 million.

Bioenergy programmes, involve strategies to achieve sustainable biomass energy supply, which include:-

- the increase of local wood supplies by various form of afforestation;
- reduction of wood energy needs through greater efficiencies of wood energy conversion and utilisation;
- substitution of woodfuels by alternative energy sources;

The impact of these programmes on greenhouse gas emissions assumes the following effects:-

- Increase sequestration at the same rate as the speed at which these programmes are implemented; and
- Decrease of emissions from land use changes at the same rate as the forests are protected from unsustainable use.

8 The Mitigation Scenario

In the mitigation scenario, due to sustainable management and use of forest resources it is expected that rate of deterioration of capacity of forests to sequester carbon will gradually diminish.

There are policy and other measures in Tanzania, necessary to mitigate environmental deterioration through the forest protection and conservation, which also have greenhouse gas sequestration effects. These include the following:

i) Introducing forest property rights, introducing bank credits of soft lending terms

ii) Diversifying energy sources including rural electrification;

iii) Encouraging the use of appropriate technologies;

iv) Conserving biodiversity;

v) Sharing of tangible benefits from the protected and conserved areas with surrounding population;

vi) Use of by-laws in controlling the cutting of wood, overgrazing, wildfire, and misuse of land;

vii) Reserving some areas in various districts for forestry development;

viii) Declaring all catchment areas to be forest reserves;

ix) Promoting forestry extension services;

x) Controlling the export of rare tree species;

xi) Carrying out research and studies on forestry and biodiversity;

The end-use side of the options include the following:-

(i) Increased efficiency in product utilisation especially timber products;

(ii) Increased efficiency in production and utilisation of bio-energy;

(iii) Improved technologies in the end use devices (e.g., improved charcoal stoves);

(iv) Substitution of wood derived products for renewable sources;

(v) Rural electrification; and

(vi) Modernisation and intensification of agriculture.

Comprehensive Mitigation Assessment (COMAP) was used to evaluate the mitigation options in terms of associated costs and greenhouse gas sequestration potential.

Nine Projects have been analysed using COMAP for Afforestation, Reforestation, Bioenergy and forest protection options. All except the Sao Hill reforestation phase II have considerably high carbon sequestration potential. The most favourable projects in terms of costs are the Sao Hill phase I, which has the highest NPV, followed by the North Kilimanjaro reforestation project and the Sao Hill bioenergy project. The Net Present Value (NPV) indicator is a measurement of economic efficiency for any investment decision making. However in evaluating forestry projects economic efficiency is not the only objective. Furthermore, there are other parameters, which makes the NPV not sufficient for investment decision making.

COMAP is being modified to capture the impact of wood energy technologies. In the absence of this component an analysis of the impact of wood energy technologies was carried out outside the COMAP process. The efficient wood energy technologies including efficient stoves and efficient charcoal kilns have proved to be effective in reducing greenhouse gas emissions from households and commercial sectors. Furthermore, fuel switching and rural electrification have also shown a significant impact in greenhouse gas emission reduction from these sectors.

9 Conclusions

This study has analysed the forestry and land use sector behaviour on the basis of the current policies on land and environment. Furthermore three scenarios have been developed on the basis of what is expected to happen in the sectors, the worse scenario being a catastrophic one where if things takes the business as usual trend then the forest resources will easily be depleted. The TFAP scenario takes into account the implementation of the current plans as scheduled while the mitigation scenario takes into account the GHG mitigation in the implementation of the plans. A Comprehensive Mitigation Analysis Process (COMAP) has been used to analyse the GHG and cost implications of the various programmes under the mitigation scenario.

The greenhouse gas mitigation analysis in the forestry sector suggests a number of ways in which sustainable management of forestry resources can be achieved. These can be grouped into two categories namely, interventions that would create public good and as such forest protection and conservation falls under this category. Such programmes can be expensive and can also take time to realise the expectations. The other category involves the establishment and management of forest plantations including sustainable harvesting of the forestry products, whether it being timber or inputs for bioenergy production. Such projects are attractive even for private investment.

Ranking of the forestry projects has been possible using economic efficiency indicators and the carbon sequestration potential of the project in the COMA. However, these indicators are not enough to tell, for example, why should a foreign company be interested to invest in a forestry project in Tanzania under a Clean Development Mechanism (CDM) or any other arrangement. This will require further studies on the individual firms' behaviour using econometrics and optimisation approach. The analysis in this study is nevertheless a good input in making selection from a bundle of forestry projects on the basis of their costs and benefits including carbon storage potential and other associated economic benefits.

Linkage of energy and forestry sector has been an important part of this analysis, for forestry resources are important inputs to the energy economy in Tanzania. For this study two types of analysis have been undertaken in relation to energy and forestry linkages, namely the bioenergy project, and the wood energy technology improvements. However, the latter analysis involved technology emissions implications rather than the implication on the carbon pool.

From the aforesaid it is recommended that the results of this study be input in the sector policies and the national action plan on climate change. It should be noted that there still exist some gaps in data and information, which is required for detailed forestry mitigation assessment. Therefore, capacity building in the relevant sectors should be enhanced so that such activities are undertaken. Bridging of data gaps, widening of methodological approaches and bridging of research needs gap should form the basis of future studies.

1 Introduction

1.1 Background

Tanzania ratified the United Nations Framework Convention on Climate Change (UNFCCC) in April 1996. The UNFCCC requires member countries to communicate to the Conference of the Parties (CoP) on different issues regarding climate change and mitigation efforts. The UNFCCC commits Parties of the Convention to develop national programmes and measures to respond to climate change. One of the key responses that countries can make is to adopt measures that can reduce atmospheric accumulation of greenhouse gases (GHG) (termed as abatement) or increase terrestrial storage of carbon (termed as sequestration).

DANIDA has made funds available to Tanzania and other SADC countries for development of methodologies and capacity building in GHG mitigation assessment. This project is being managed by the UNEP Collaborating Centre on Energy and Environment (UCCEE), and is being funded by DANIDA as part of a larger effort to support mitigation studies in developing countries. The DANIDA supported study will facilitate a complementary study on greenhouse gas (GHG) mitigation in the forestry and land use sectors in Tanzania.

Consumption of woodfuels (wood and charcoal), mainly to satisfy household demand, largely dominates the energy economy of Tanzania. About 90% of all primary energy consumed in Tanzania is biomass-based, in the form of fuelwood, charcoal, and agricultural residues. The commercial and industrial energy sectors in Tanzania are small in relation to the household sector. As can be expected, much of the demand for fuelwood is satisfied through deforestation. This relationship between forestry and the energy sector forms the basis for a cross-sectoral analysis, linking the two sectors and exploring synergies for GHG mitigation within the sectors.

Tanzania, like most developing countries, has very low emissions from fossil fuel use, while the forest and land-use sectors have relatively higher emissions. Any policies geared to the significant reduction of current and future emissions as well as the sequestration of carbon from the atmosphere should target the forest and land-use sectors.

Objectives of this study are to analyse the role of the land use sectors (especially forestry) on mitigation of greenhouse gases. Special emphasis is on the relationship between forestry and energy supply from biomass. This is a follow up study on an earlier effort, which worked on mitigation options in the country without an in-depth analysis of the forestry and land use sectors. Method adopted in this study involves the examination of the baseline and mitigation scenarios. Three scenarios developed include a “catastrophic” scenario whereby despite the existence of the policies and plans the sector takes a business as usual path and experiences poor implementation of policies. Another scenario is the "enhanced TFAP scenario," which assumes implementation of the Tanzania Forestry Action Plan, but since its time horizon is up to the year 2008 we project it to 2020. The third scenario is the mitigation scenario, which improves on the previous two scenarios by undertaking mitigation actions.

This report has eight chapters beginning with some general background information in chapter 1. Chapter 2 provides an overview of climate change studies in Tanzania. Chapter 3 is an overview of the forestry and land use sector while Chapter 4 covers energy sector and its relationship to forestry. Chapter 5 discusses assumptions for the scenarios and policies relevant to the land-use sectors. Chapters 6 to 8 deal with the construction of the three scenarios, namely the catastrophic scenario, enhanced TFAP scenario and the mitigation scenario. Chapter 8 provides conclusions, discussion of crosscutting issues and recommendations.

1.2 Geographical location and climate

Tanzania came into existence in 1964 when Tanganyika and Zanzibar were united. She is an East African country situated between latitudes 1^0S and 12^0S, and longitudes 29^0E and 41^0E with an area of 942,784 km^2. About 61,495 km^2 of the area constitutes inland water- bodies (water resources) including parts of the three big East African lakes - Victoria, Tanganyika, and Nyasa (Malawi).

The climate is mainly influenced by Tanzania's location close to the equator, the impact of the Indian Ocean and the physiography in general. About 65% of the country receive more than 750 mm annual rainfall while the remaining 35% receives less than this. Most parts of the country experience seasonal rainfall falling normally in one season followed by severe longer dry seasons. Except in the highlands, which sometimes endures frosts during cold seasons, the temperature does not fluctuate significantly throughout the year.

1.3 Demographic and socioeconomic profile

1.3.1 Demography

In 1995, the population was estimated to be about 28 million people giving a population density of 29 persons per square kilometre. According to the 1988 census, the population is growing at an average rate of about 2.8%. About 75% of the population reside in rural areas and only 25% reside in urban areas. Table 1.1 shows the population estimates for the period 1967-1993.

Table 1.1 Tanzania population estimates 1967 - 1993 (million inhabitants)

Place/Year	1967	1978	1988	1992	1993
Mainland	11.96	17.04	22.49	25.15	25.87
Zanzibar	0.36	0.48	0.64	0.72	0.74
Total Population	12.32	17.52	23.13	25.87	26.61
Pop. Density/sq. km	14	20	26	29	29

Source: (3, 22)

1.3.2 Economy

The mainstay of the Tanzanian economy is agriculture. In 1992 agriculture and livestock activities contributed to about 41 % of the Gross Domestic Product (GDP). The major export cash crops are cotton and coffee. The manufacturing industry accounted for about 8 % of GDP in 1992 while the mining industry accounted for only 1.2 % of GDP.

Table 1.3: GDP growth trends for Tanzania (percentage)

Sector	Projected				Actual		
	1994	1995	1995	1996	1991	1992	1993
GDP Growth	4.4	4.8	5.8	6.3	4.3	2.6	4.1
Agriculture	2.7	4.1	5.2	5.8	0.0	2.2	7.3
Manufacturing	5.7	6.5	6.9	7.4	10.7	2.1	2.1
Mining	8.9	10.6	11.4	12.3	26.8	15.5	-19.1
Constr.(Elec. & Water)	7.5	5.3	6.0	6.7	40.0	1.4	-4.2
Services	5.0	4.9	5.9	6.4	0.1	3.2	4.0

Sources: (3)

For the past decade Tanzania has experienced several economic hardships including large balance of payment deficits, substantial international debts (over US$ 5 billion), government budget deficits and high rates of inflation, at times up to 35%**.** This has put Tanzania among the poorest countries in Africa, with annual per capita income of US$ 110 in 1990.

Table 1.4 Sectoral contribution to the GDP (Million US$)

	1992		1993		1994		1995	
	Mill. US$	%	Mill. US$	%	Mill. US$	%	Mill. US$	%
Exchange Rate (1 US$ = Tshs)	284.40		454		514		577	
Agriculture forestry and fishing	1,940.51	54.8	1609.183	54.8	1844.322	54.8	2096.402	57.1
Minerals	67.44	1.9	50.08517	1.4	52.52328	1.6	48.28055	1.4
Manufacturing	290.79	8.2	230.6133	7.9	245.8903	7.3	247.0944	6.7
Electricity and water	74.82	2.1	73.72001	2.1	73.63489	2.2	75.81707	2.2
Construction	167.86	4.7	144.671	4.9	168.2476	5	109.1142	3
Wholesale and retail trade	573.49	16.2	522.9689	14.7	497.9632	14.7	515.5715	14.9
Communication and transport	226.20	6.4	203.6813	6.9	244.3947	7.3	266.359	7.3
Financial, insurance & business services	160.44	4.5	345.2401	9.7	320.9165	9.5	318.8408	9.2
Public administration and other services	179.85	5.1	136.915	4.7	161.7765	4.8	184.3213	5

Source: (26,27)

Between 1980 and 1995 Tanzania implemented several structural adjustment programmes all aimed at expanding the economy base at an average growth rate of 6 % per annum. Since 1985 the GDP has grown at an average rate of about 4%. Currently, Tanzania is committed to creating an enabling environment towards a free market economy.

1.3.3 Relevance of land-based sectors to the economy

The national statistics consider the agricultural sector to include crop production, livestock, fisheries, forestry and wildlife. The contribution of the conventional forest sector to national income using market prices is slightly less than 5% (6). However, the sector has a larger number of attributes, products and services, which do not lend to market value. Furthermore, its linkages with the other sectors such as the agriculture and energy sectors make forestry indispensable for the economy that is mainly agrarian and rural.

Forests in Tanzania can also be classified into unproductive, productive, protected and community forests. Despite the importance of the forestry sector, its contribution to GDP is grossly under-estimated. Forests provide biomass energy for households, protect important watersheds for hydropower dams, conserve soil from erosion, and significantly provide employment opportunities.

2 Overview of Other Climate Change Studies

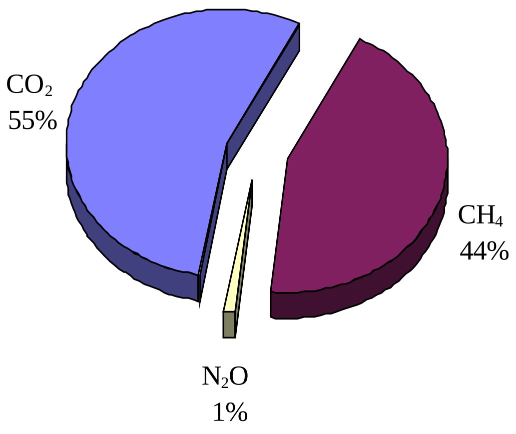
2.1 Inventories of greenhouse gas emission

In 1993, Tanzania carried out a study on sources and sinks of greenhouse gases (GHG). The objective of the study was to establish an inventory of sources of emissions and removal by sinks of GHGs in Tanzania (2). The initiative was funded by the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP). UNEP and the U.S. Country Studies Programme provided support in the form of training, review work, data validation and information.

Carbon dioxide emissions from Tanzania in 1990 amounted to 55,208 Gg CO_2. The Land-use change and forestry sector contributed about 95%, the energy sector contributed about 4%, and industrial sector contributed less than 1%. Per capita CO_2 emissions were about 2.2 tonnes. Total methane (CH_4) emissions in 1990 were about 1,809 tonnes, which is about 70 grammes per capita. Emissions of methane came from combustion of biomass, livestock management, rice production, waste management, and coal mining activities. Carbon monoxide, nitrogen oxide, and nitrous oxide emissions came from biomass burning.

The calculation of total emissions, using the Global Warming Potential Index (GWP), indicates that emissions of CO_2 contributed 55% to potential warming due to the 1990 emissions, CH_4 provided 44%, and N_2O provided 1% (Figure 2.1).

Figure 2.1 Important greenhouse gases emitted in Tanzania



Land-use changes and forestry sector made the largest contribution (53%) towards the warming that may result from the 1990 emissions of trace gas in Tanzania, followed by agriculture (33%), energy (13%), and waste management (1%). Industrial processes contributed less than 1% of potential warming (Figure 2.2).

Table 2.1 Greenhouse gas emission in Tanzania in 1990 (Gg)

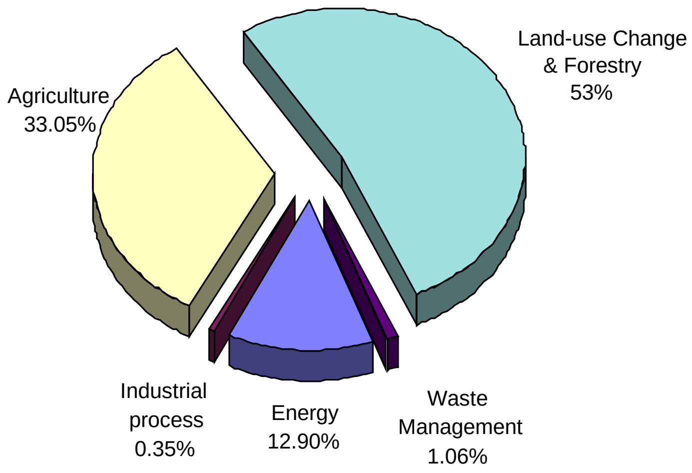
	Gigagrams (Gg)				
	Carbon Dioxide (CO_2)	Methane (CH_4)	Carbon Monoxide (CO)	Nitrous Oxide (N_2O)	Nitrogen Oxide (NO_2)
Module 1: Energy					
Fossil fuel combustion	1,938.976	0.526	78.86	0.0272	13.845
Methane and other gases from traditional biomass fuel burned for energy		424.481	1,550.00	1.9086	54.110
Methane emission from coal mining and handling		0.821			
Emission from natural field reserves of carbon dioxide	1,260				
Subtotal module 1	1,940.236	425.828	1,628.87	1.9358	67.955
Module 2: Industrial Processes					
CO_2 from cement, pulp, paper proc.	349.421				
Subtotal module 2	349.421				
Module 4: Agriculture					
Methane emission from animals and animal manure		8.057			
Methane emission from rice production		84.756			
Savanna burning, release of non-CO_2 trace gases		47.825	1,255.39	0.5920	21.39
Burning of agricultural residues		323.002	1,053.47	0.573	20.728
Agricultural soils/fertilizer use and manure management		8.057		0.5673	
Subtotal module 4		1,335.915	2,308.87	1.7323	42.118
Module 5: Land-use Change & Forestry					
Forest clearing activities	727.060	2.483	27.15	0.017	0.617
Abandonment of managed lands	-1,930.5				
Emission from Forests subject to human activity	55,937.51				
Removal from forest subject to human activity	-1,814.77				
Others (Shifting cultivation and dams)		0.57	4.17	0.005	0.139
Subtotal module 5	52,919.30	3.602	31.33	0.022	0.756
Module 6: Waste					
Municipal solid waste disposal		8.363			
Municipal wastewater treatment		2.308			
Others (industrial wastewater)		33.108			
Subtotal module 6		43.779			
Total	55,208.957	1,809.124	3,969.08	3.6901	110.829
Global Warming Potential (GWP)					
100 years integration	1.00	24.50		320.0	
Gg CO_2-equivalent	55,208.957	44,323.538		1,180.832	
Percent	55	44		1	

Source: (2)

Notes: (1) CO_2 estimates were obtained by a "top-down" approach. A technology-based approach gives slightly higher estimates by up-to 10%.

(2) Some figures are slightly higher or lower by up to 0.25 Gg due to rounding-off at various stages during the calculations.

Figure 2.2 Sectoral contribution to GHG emissions



In general Tanzania's emissions are not significant compared to developed countries, but the results lead the country to design measures that will promote sound technologies for sustainable development goals.

Table 2.2 Comparison of Tanzania's GHG emissions with world emissions (Gg CO_2 equivalent)

	Tanzania	Zimbabwe	South Africa	Mexico	Ukraine	Global
Energy	12,992	19,745	377,523	342,759	807,241	22,000,000
Industrial process	349	617	5,900	11,621	31,756	1,300,000
Agriculture	33,284	5,876	21,683	48,016	55,370	7,400,000
Land-use Change & Forestry	53,015	-142,312	3,240	116,882	-56,938	4,000,000
Waste Management	1,073	2,243	12,495	12,887	22,418	1,600,000
Total	100,713	-113,831	420,841	532,165	859,847	36,300,000

Source: (29)

2.2 Greenhouse gas mitigation

As a follow-up to the greenhouse gas emissions inventories, in August 1994, Tanzania started another study on greenhouse gas mitigation options. The study was funded by Deutsche Geselschaft fur Technische Zusammenarbeit (GTZ). UNEP Collaborating Centre for Energy and Environment provided backstopping services for the project. This included inputs in terms of methodological aspects of the implementation of the project.

Sources of greenhouse gas emission analysed included energy, industrial, transport, forestry and land-use, agriculture and livestock, household, commercial, and informal sectors. A sectoral analysis was done and number of technological and non-technological options have been identified and will serve as input to various national plans and communication.

2.2.1 Sectoral assessment

Identified mitigation options include, among others, the application of increased 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 were fuel switching in the transport sector, transport management and optimisation in transport modes, afforestation, forest management, and urban tree planting.

Table 2.3 Some GHG mitigation options

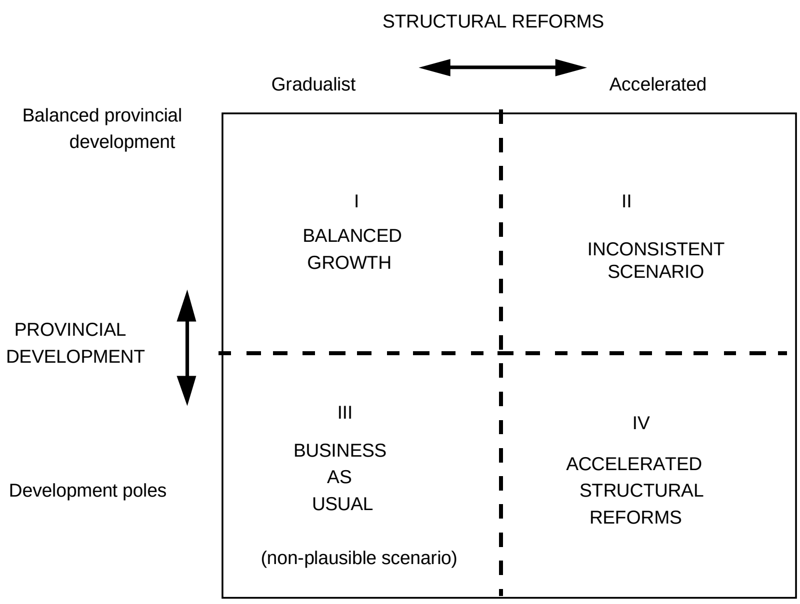
Sector	Option	Description
Energy Supply	• Advanced electricity generation technologies • Efficiency improvements • Charcoal production • Coal mining • Renewable technologies	• Install 230 MW of combined-cycle power plants instead of simple cycle gas turbines • Increase the efficiency of existing power 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
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 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	• Improve technical efficiency of vehicles • Improve traffic flow, increase vehicle load factors, improve vehicle maintenance, traffic operation, training and management • Rehabilitate and expand the rail system • Implement city trains in Dar es Salaam
Household and Service Sector	• Electrical appliances • Cookstoves • Waste management	• Improve efficiency of electrical appliances • Increase efficiency of biomass cookstoves • Waste management including landfills and waste water treatment
Agriculture and Livestock	• Agricultural practices • Livestock husbandry	• Reduce methane and carbon emissions through better practices related to fertilizer application, rice cultivation, and 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 regeneration and agroforestry practices • Maintaining or increasing carbon sequestration through better soil management and sustainable agricultural practices

2.2.2 Macroeconomic 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. These include external uncertainties concerning the evolution of export commodity prices, the foreign debt service, and external development support; and internal uncertainties including structural adjustment policies, provincial development strategies, land allocation policies, agricultural development priorities and the exploitation of abundant natural resources.

The Cross-Impact Matrix method starts by establishing a list of pertinent elements that make up the building blocks of the scenarios. These focus on the key interest relationships among those elements, and methodically state whether that relation exists in each of the two directions between each possible pair of elements. The relation is expressed simply by the presence or absence (zero or one respectively) of any direct relationship between a pair of elements. As a result, a structural matrix is defined, representing the links between the systems key elements. A consistent combination of the different outcomes results in a definition of the different scenarios. Figure 2.3 shows the scenarios resulting from the Cross Impact Matrix analysis.

Fig. 2.3 The structure of Tanzania's scenario for future development

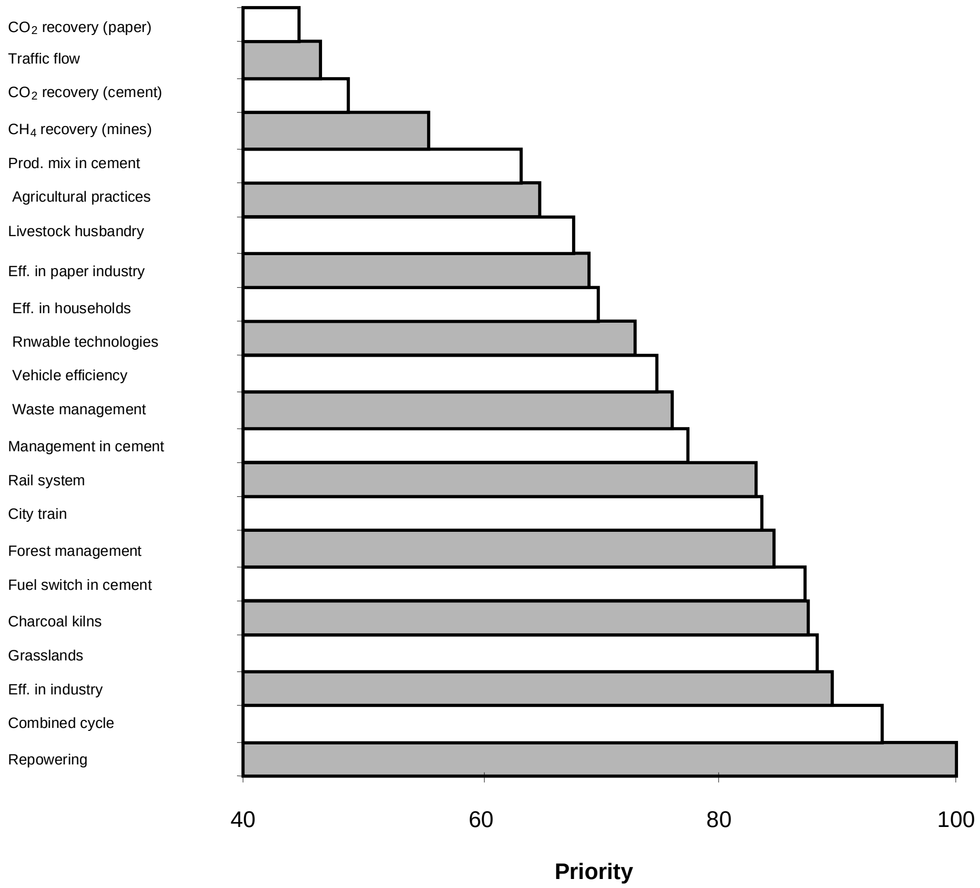


The most likely scenario for the long-term development of Tanzania can be characterized by the predominance of structural reforms in the short-term, followed by a more balanced growth strategy in the long-term. Therefore a combination of the above scenarios results in a composite scenario. The economic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

2.2.3 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 2.4 shows the results of the ranking process.

Fig. 2.4 Ranking of mitigation options



The study on Technological and Other Options for the Mitigation of GHG in Tanzania did not cover the forest and land use sectors sufficiently, it provided an overview of the inherent problems in the sector and an outline of possible mitigation options.

2.3 Vulnerability and adaptation assessment

Tanzania is conducting another study, under support of the U.S. Country Studies Programme. The study started in October, 1994 and after the development of climate change scenarios for Tanzania assesses the potential impact of climate change on water resources; coastal resources; agriculture, particularly production of maize, coffee and cotton; grassland and livestock; forestry; and health. The study also will assess the options and potential measures for adaptation to climate change.

2.4 National Action Plan on Climate Change

In order to integrate the findings and recommendations from country studies into national programmes Tanzania is undertaking the development of a National Action Plan. The development of the National Action Plan, supported by the U.S. Country Studies Programme, involves the assessment of the national planning process and its relevance in development of the climate change action plan. Sectoral assessment included the energy, industry, transport, water resources, agriculture, and coastal resources. Barriers to implementation and methods for overcoming them were also studied.

The plan will take into account and compliment Tanzania’s economic and environmental policies and plans. The plan will be a vital guidance tool for the government in implementing various measures under various programmes and plans. Among the key sectors to be addressed in the plan is the energy sector. Tanzania’s energy economy is characterized mainly by the dominant role played by biomass-based fuels and imported crude oil and petroleum products. The plan will look into various policy measures and strategies that will foster application of alternative energy sources, energy efficient technologies, enhanced exploitation of renewable energy sources and technologies.

3 Overview of Forestry and Land-Use Sector

3.1 Dynamics of the forestry and land use-sectors

3.1.1 Vegetation distribution and change

Mainland Tanzania comprises a wide range of vegetation types, including closed forests, mangroves, many types of woodlands, grasslands, swamps and bogs, cultivated lands and active induced vegetation, and areas of semi-desert. About 50 % of the total land area is forest and woodland, 40% is grassland and shrub and 6 to 8 percent is cultivated. The terms forest and woodland are comprehensive and only 3 percent of the country is covered by dense closed forest. Closed canopy forests occur in very restricted areas and are mostly limited to uplands and coastal lowlands. However, the most common types of vegetation are miombo woodlands and related wooded grasslands. The areas covered by each of vegetation class have been summarized in Table 3.1. However, it is important to note that estimates of vegetation areas are based on limited inventories.

Table 3.1 Vegetation distribution and changes during 1947-1990 (kha)

Vegetation class types	1947	1956	1976	1990
Tropical Closed Forests	7727[1]	1885	1455	1100[2]
Mangrove Forests	93	80	80	80
Miombo Woodlands	35392	38706	26702	25616
Wooded Grasslands (Savanna)	19746	20037	14205	16662
Bushland/Thickets	9481	10551	9878	7464
Thickets	772	569	727	784
Grasslands	6049	4011	4770	6295
Desert/Semi Desert	867	460	491	163[3]
Cultivated/Abandoned Lands/Settlement	8407	12227	28481[4]	28215
Swamps, Bogs and Water Bodies	5975	5983	7720[5]	8130
Total	94509	94509	94509	94509

Source: (2)

Note: (1) *Desert, semi desert, and bare lands decrease soon after the rainy season and increase during prolonged dry seasons. Depending on the season when the area maps were annotated, this category seems to decline with time but in strict sense the so called desert or semi desert may have remained the same or increased.*

(2) *From 1947 to 1956 forests were cleared with the aim of establishing cash crop plantations, and tse-tse fly eradication.*

(3) *Closed broadleaf forest has been reduced at the rate of 20,000 ha per annum between 1976 and 1990 (18). Acreage differences between 1976 and 1990 refer to the total changes of typical forestland to other types of land uses, including other forms of forests.*

(4) *Agrarian reforms including the policy of 'Ujamaa Villages' and specific campaigns such as "Agriculture for Survival" from 1973 to 1976, and the abandoned large-scale managed lands such as cashewnut and sisal estates increased land area under rural settlement and fallow.*

(5) *A portion of grasslands and agricultural lands has been converted to irrigation such as in the Usangu basin where rice cultivation is undertaken.*

(6) *To rescue mangrove forest from over-exploitation of 93.24 kha (in 1947) for salt pan making, charcoal production, construction pole yield, and fuelwood production for fish smoking, the Government had intervened by gazetting mangrove forests under forest reserves. This increased the acreage from 79.77 kha (in 1956) to 79.90 kha (in 1990).*

During the period of 1976 through 1990, 24.4 percent of original tropical closed forest cover was transferred to other classes as follows:-

(i) 115 kilo-hectares (kha) were converted to permanent agricultural land and pasture. This was more likely a result of population pressure rather than planned land-use change;

(ii) 38 kha were converted to secondary forest; that is thickets (8 kha) and bushland/thickets (30 kha); and

(iii) 202 kha converted to wooded grassland or fragmented forest, which in turn changed to other land cover as an intermediate stage towards permanent agriculture and pasture.

Table 3.2 shows the changes in reserved forests from 1947 to 1990.

Table 3.2 Land area covered by reserved forests during the period of 1947 - 1990

Sector specific data by forest management type	1947 (kha)	1956 (kha)	1972 (kha)	1990 (kha)
Productive forests	1059	5726	10535	11025
Protective forests	151	999	1570	3184
Total	1210	6725	12105	14209

Sources: (18, 19)

3.1.2 Distribution of forest resources

Forest reserves or "gazetted" forests include "productive", "unproductive" and "protective" forests and land area under national parks and game reserves. "Productive" forest areas are whose terrain and soil conditions are suitable for production of wood and other forestry products on a sustainable basis. "Unproductive" forest areas are located on terrain too steep, rough or subject to periodic or permanent incantation, which makes forestry management impractical. "Protective" forest areas have been created to protect water catchments, valuable ecosystems and rare species. Unreserved forests in public lands are the most affected forest types by human activities.

A large proportion of the miombo woodlands is the tsetse fly infested and it occurs over wide areas of west central Tanzania. Mangrove forests are also important resources, which are environmentally significant even though they occupy only a relatively small area. The types of forests present in Tanzania are shown in Table 3.3.

Table 3.3 Forest resources in Tanzania (1990)[a]

Forest Type	Total Area With Mature Stock	Total Area Under Fallow	Biomass Density (m^3/ha)		Mean Annual Increment	Total Biomass Stocking
	(kha)	(kha)	Mature	Fallow	(m^3/ha)	(mill. m^3)
Miombo Woodlands	35,414	3,546	32	12	2-4	1,176
Closed Forests	1,100	240	185	59	5-10	218
Mangrove	120	0	120	0	4-6	14
Shrubs and Thickets	525	22	10	4	0.3-0.7	5
Industrial Plantations	98	5	350	50	15-25	35
Village Plantations	100	6	135	18	12-15	14
Total	37,317	3,819				1,458

Source: (3)

[a] Figures provided may not coincide with distributions provided in other sources

3.2 Deforestation, its causes and impacts

The term deforestation as applied for the purpose of estimating GHG emissions includes harvesting for forest products and clear felling. Selective logging is adjusted for the section intensity and the area estimated on the basis of clear felling equivalence. Table 3.4 provides a summary of the deforestation rates for the main forest types in the country.

Table 3.4 Depletion of Forest Resources 1990

Major Types of Land-use	Area in 1982 (mill. Ha)	Area in 1990 (mill. ha)
Water Catchment Protection	1.0	0.9
Forestry and Woodland Exploitation	37.2	37.3
Cultivation (Small/Large Scale)	4.6	5.4
Rough Grazing (Induced Vegetation)	44.2	43.1
Roads, Rivers and Urban Settlements	1.5	1.9
Fishing, Hydropower and Navigation	6.0	5.9
Total	94.5	94.5

Source: (3)

Although Table 3.4 shows trends in land use activities contributing to deforestation the information is not detailed enough to provide one with the ability to analyse GHG issues from land use sectors (including mitigation analysis). For example woodland exploitation figures does not reflect biomass used for various end uses such as charcoal and firewood. Table 3.5 is included to show the recent analysis of deforestation and forest degradation as relevant to GHG emissions. After adjusting the degraded areas to depletion equivalence, they gave a conservative estimate of 749,000 ha deforested in Tanzania in 1990.

Table 3.5 Exploitation of forest resources for various land-uses ('000 ha)

Forest type	Agriculture	Harvesting	Pasture	Other	Total Area[a]
Mipmbo Woodlands	302	249	100	25	676 (1.69)
Closed Forests	20	20	7	2	49 (3.50)
Mangrove and Coastal Thickets	1	3	0	0	4 (4.00)
Other Woodlands, Shrubs and Thickets	10	1	3	1	15 (8.38)
Industrial Plantations	0	1.3	0	0.7	2 (2.04)
Village Plantations	1.5	1	0	0.5	3 (2.24)
Total	334.5	275.3	110	29.2	749 (1.78)

Source: (28)

[a] *The figure in parenthesis is annual rate of loss in percent*

Land-use changes result from expansion of human settlements, the need for woodfuel to support rapid growing urban population, and the need for permanent land to support crop production. Consequently, the land area under rough grazing and water catchment forests has steadily been decreasing.

3.2.1 Forest clearing for permanent cropland and pasture

Conversion of forests to permanent croplands or pasture is prevalent in public lands in unreserved forests although at times encroachment of reserved forests has been occurring. The changes in land area under agriculture are shown in Table 3.4 and Table 3.6. It is estimated that 88.6 kha of forest area was converted to permanent cropland and pasture in 1990 (18). However, the total change arrived at this way makes reference to arable land and settlements over 15 years. Okello (18) estimated the 10-year forest conversion to permanent agriculture and pasture to be comprised of 58.9 kha of broadleaf closed forest, 594.8 kha of miombo woodlands, and 232.4 kha of bushland/thickets. In order to arrive at reasonable estimates of sources and sinks of greenhouse gas emissions, a number of assumptions have been made. These assumptions are:-

a) Conifer forests are not susceptible to conversion to agricultural land. Thus, 88 percent of clearing occurs in broadleaf logged forests and the remaining 12 percent in unproductive closed forests. In the case of open forests 78 percent of clearing occurs in productive forests with the remaining 22 percent in unproductive forests.

b) Not all cleared aboveground biomass is burned. About 75 percent of total cleared biomass is collected as woodfuel. Approximately 20 percent of aboveground biomass is burned in fields (where 10 percent of the burned carbon remains on the ground as charcoal). The remaining cleared biomass (5 percent of aboveground biomass such as foliage, twigs and humus) decays in fields over an average of 10 years releasing one-tenth of its carbon content on dry weight basis annually (17).

c) Aboveground dry matter densities in tropical forests before clearing are 202 tonnes of dry matter per hectare (t dm/ha), 59.46 t dm/ha, and 185 t dm/ha for undisturbed, logged, and unproductive broadleaf closed forests, respectively. As for undisturbed, logged, and unproductive conifer closed forests, aboveground biomass densities are 130 t dm/ha, 60 t dm/ha, and 110 t dm/ha respectively (15), and 32 t dm/ha and 12 t dm/ha in open and other forests for productive and unproductive forests, respectively (19).

d) After the clearing and conversion of forest to permanent cultivated land aboveground dry matter densities in tropical forests depend on whether the cleared land has been turned into cropland or pasture. Openshaw (19) has estimated densities of 18 t dm/ha for agricultural crops in closed forest, 10 t dm/ha in open forests, and 4 t dm/ha for pastures and crops in cleared miombo woodlands.

e) Emission ratios used in biomass burning calculations are a result of extensive work done by other researchers elsewhere (17).

The agricultural land use pattern has been projected on the basis of information from the National Sample Census of Agriculture 1973, and projections made by various sources. Table 3.6 shows the agricultural land use pattern.

Table 3.6 Agricultural land-use pattern 1982 - 1990

Sector specific data by land-use	Area in 1982 (kha)	Area in 1990 (kha)	Change (%)
Subsistence farming	3,047	4,186	+ 37.4
Large scale plantations	1,151	1,020	- 11.4
Area under short fallow[1]	402	922	+129.4
Area under long fallow[2]	22,116	20,453	- 7.5
Total	26,716	26,581	- 0.5

Sources: (18, 19)

Note: (1) Area under short fallow supports shifting cultivation. This area increased by about one and half times between 1982 and 1990. This increase is the result of a reduction in areas under long fallow.

(2) Long fallow areas are also partial pasturelands in some places. Ordinarily, they regain to at least 75 percent of original aboveground biomass cover in 25 years. However, because some of these areas are subjected to other land uses, regrowth is less.

3.2.2 Forest clearing for energy supply

Total annual fuelwood and charcoal use is estimated at 32 million cubic metres. Only 1/3 of this is obtained from clearing the forests for charcoal and fuelwood, most of it from miombo woodlands. The rest may be from agricultural clearing. Assuming one hectare can produce

50 m^3 of charcoal and fuelwood, it means that 200,000 hectares of miombo woodlands is required to produce 10 million m^3. This is however a conservative estimate.

3.2.3 Impacts of deforestation and land degradation

The rate at which the forest area is being converted to other land-uses has been increasing with the rapid increase in population, which is mainly land dependent (20). Forestland is converted to agricultural land as well as depleted for production of woodfuel, especially charcoal. Other factors that contribute to deforestation and degradation include logging, overgrazing, and forest fires.

Another explanation for causes of deforestation unique to Tanzania lies in the institutional and social definition of property rights (6), as applied to rural resources. Historically, many communities in Tanzania have been pastoralist or peasant settlements and have been very scattered such that claims to property have not been common. Forest resources have traditionally been treated as common property. The available forest resources posed no constraints to the peasant in Tanzania as long as they were relatively abundant. The increased population gradually puts heavier pressure on this resource. This is because fuel is needed for cooking, fodder is needed for animals, more of the forest is used as pasture, more forest is cleared for crops. Wood fuel is also needed for drying tea and tobacco mainly for export, and there is the fast growth of the urban markets for energy from wood, each placing a demand on the forest resource.

Estimates of the deforestation rate in Tanzania have been put forward by various sources, but there has not been a concise study to quantify the rate at which forests are being converted to other land uses or being degraded (6). The Forest Division has estimated that in the early 1980s, the rate of deforestation was between 300,000 and 400,000 ha/yr. Ahlback, puts the figure at about 600,000 ha/yr. for the early to mid 1980s, although this was mainly based on a high estimate of 2 m^3 per capita consumption of woodfuel. The FAO estimates the annual deforestation for the period 1981 - 1990 at 438,200 ha/yr. Given the fact that the rate has been increasing over the period, this estimate would tend to support a thesis of a high estimate during 1990.

Some of the key element of the problem of deforestation and environmental degradation in Tanzania as put forward by studies (6) follow the classical rural underdevelopment paradigm. With a rapidly increasing population which demands more and more agricultural land for food production as well as for producing more cash crops. However, declining productivity, due to poor technology and lack of capital will lead to a rapid depletion of forestland. Extensive agricultural expansion with less intensive agriculture leads to the encroachment of previously forested land. The two decades proceeding the base year (1995) saw agricultural land productivity decline at a rate of 1% per year. The area under cultivation will double in less than 20 years, just to meet the food requirements of the country as well as cash crop production. As for energy demand charcoal, mainly for urban population and firewood for the rural population is the main energy sources, largely used by households for cooking and to some extent by the commercial and informal sector for the same purposes. Some of the woodfuel demand is met by direct clearing of forests while some of woodfuel and other biomass is obtained during conversion of forest to agricultural land.

3.3 Contribution of the forestry sector to the economy

The forestry sector contributes significantly to Tanzania's economy. It generates about 10% of the country's registered export and employs some 730,000 persons per year. Although its officially recorded contribution to GDP in 1987 was only Tshs. 1.7 billion (1-2% of GDP) (23), its real contribution is underestimated as most consumption of wood, particularly fuelwood is unrecorded.

Charcoal and firewood from the forest areas represent 94% of the consumption of forest products.(Table 3.7) The table shows that there was a substantial increase in the recorded consumption for each category of forest products. In all wood product categories, the growth of consumption far exceeds the population growth. Such a demand for wood product consumption exerts a heavy pressure on the forest sector. Logging and procurement of woodfuel, especially charcoal, lead to degradation and deforestation of significant amounts of existing forests. Table 3.8 shows the wood milling information for the years 1992-1995.

Table 3.7 Wood production in Tanzania in 1990

Product	Volume (1x1000m^3)		% Share	% Change since 1980
Roundwood	34,276			46
Firewood and charcoal	32,240		94.1	45
Industrial	2036		5.6	72
Processed wood	208			53
Sawn-wood	156			28
Wood-based panels	15			150
Paper and paper board	37			🕓
Net round wood trade	-			-

Source: (6)

Table 3.8 Wood milling data

Plant	Wood Sales in Cubic Meter		
	1993	1994	1995
Sao Hill Sawmill	25923	20815	16919
Fibre Boards Africa	36007	22565	24527
Sikh Sawmills	2790	2408	2776
Tembo Chipboards	20366	12755	8048
Kiltimbers	18796	7950	8228
Mkata Sawmill	-	286	773
Tabora Msitu	1792	1238	773
Giraffe Extract	258	880	48
Mingoyo	1521	1744	-
Mtibwa	-	559	876

Source: (25)

Since data is scarce, only rough estimates can be made on the benefits accrued locally, nationally and globally from an average hectare of miombo woodland. It is estimated that (23), at the local level the present value of forest production is USD 1,050 per ha. This is based on the value of sustainable harvesting of wood, beekeeping and other benefits associated with forests such as fruits, mushrooms and edible fibres, medicinal products, game meat, soil and water conservation. At the national level, the value of forests is estimated to be USD 750 per ha on the basis of royalties collected from exports, and earnings from tourism. At the global level, the value is calculated to be USD 1,500 per ha based on the recycling and fixing of CO_2. These estimates indicate that the economic benefits from forests and woodlands are greater than generally assumed and that under certain circumstances, forests could be the most profitable form of land use. The estimated gross values of the output of forest based activities (1988 - 2008) are shown in Table 3.9 as adapted from TFAP (10).

Table 3.9 Estimated gross value of output in forest based activities 1988-2008

	TFAP Targets			
	1988		2008	
	Million Tsh.	Percent(%)	Millions Tsh. in 1988 Prices	Percent
Fuelwood & Charcoal (1)	9,600	34.8	17,600	15.3
Building poles (2)	900	3.3	1,800	1.6
Forest industries (3)	3,700	11.6	12,400	10.8
Wood total	14,200	49.7	31,800	27.7
Honey and beeswax (4)	1,100	4.0	2,200	1.9
Wildlife based activities (5)	9,700	35.1	74,300	64.5
Others (6)	3,100	11.2	6,800	5.9
Non wood total	13,900	100.0	83,300	72.3
Grand total	27,600	100.0	115,100	100.0

Source: (10)

Note:

1. *Subsistence consumption valued at cost, market production in market price.*
2. *In market prices; includes also other poles.*
3. *Mechanical wood industries pit sawing, pulp and paper production, joinery and furniture.*
4. *In market prices.*
5. *Includes wildlife-based tourism, and legal and illegal cropping, hunting and trade.*
6. *Includes wattle extracts, fruits and medicinal plants, etc.*

3.4 Greenhouse gas emissions from forestry and land-use

3.4.1 Categories of land-use changes resulting into GHG emissions

Changes in land-use often results in changes in the quantity of biomass on the land and produce a net exchange of greenhouse gases. Since biomass is about 45 % carbon by weight, forest clearing leads to release of carbon dioxide to the atmosphere. Clearing by burning also leads to instantaneous release carbon dioxide, methane, carbon monoxide, nitrous oxide and oxides of nitrogen, NO_x.

Soil disturbance does lead to greenhouse gas emission. Forest conversion into pasture or cropland results in release of soil carbon through oxidation of organic matter contained in the soil. In estimating greenhouse gases from land-use changes, activities that contribute to these emissions are divided into several categories. These are;

- Forest clearing for permanent crop land or pasture
- Conversion of grassland to cultivated lands
- Abandonment of managed land
- Forest management
- Shifting cultivation
- Forest degradation due to air pollution
- Flooding lands

3.4.2 The 1990 estimation of GHG emissions from forestry and land use

The 1990 greenhouse gases inventory formed the basis for all projections of carbon dioxide emissions from forestry and land-use (3). Clearing of forest and grassland for permanent agriculture and livestock development, savanna burning, and overgrazing are major contributors of greenhouse gas (GHG) emissions (3). The base year CO_2 emissions have been extrapolated using, demographic variables, economic factors, intensity of land-use, yields per unit area, and other biophysical factors. The following assumptions have been made in making these projections:-

(a) CO_2 emissions increase with area of forest and grassland cleared permanently for land-uses other than seasonal farming;

(b) the decrease of the permanent forest and grassland area has a bearing on population, urbanization and economic growth;

(c) projection intervals have been restricted to 10 years in order to accommodate rapid technological changes; and

(d) policies and strategies currently under way, will contribute towards reducing the area of abandoned managed land and deforestation rate of natural forest.

In estimating future emissions the following empirical formula has been used (3, 4).

$$CO_{2\ target} = CO_{2\ base} \times (1+ Factor)^{Time}$$

Where

$CO_{2\ target}$	=	CO_2 emissions in any year of projection (Gg)
$CO_{2\ base}$	=	CO_2 emissions in base year for projections (Gg)
Factor	=	escalation factor based on socio-economics (%)
Time	=	one decade (10 years)

Table 3.10 provides a summary of GHG emissions from forestry and land use in 1990.

Table 3.10 Emission and removals due to land-use changes in Tanzania (Gg)

Sector specific data by source or sink activity		CO_2	CH_4	NO_x	N_2O	CO
		Gigagrams (Gg)				
Forest clearing for agriculture	On-site burning	569.03	2.485	0.617	0.017	27.158
	Decay of cleared biomass	158.03	N.A	N.A	N.A	N.A
	Sub-total (1)	727.06	2.485	0.617	0.017	27.158
Abandonment of managed lands	Wooded grasslands	-1353.00	N.A	N.A	N.A	N.A
	Tropical open forests	-577.50	N.A	N.A	N.A	N.A
	Sub-total (2)	-1930.50	N.A	N.A	N.A	N.A
Management of forests	Wood exploited informally (woodfuel, and clearing for agriculture)	55937.51	N.A	N.A	N.A	N.A
	Plantation forests	-1351.35	N.A	N.A	N.A	N.A
	Natural forests subject to human activity (shifting cultivation)	-364.32	N.A	N.A	N.A	N.A
	Village woodlot, and urban and rural tree planting	-99.10	N.A	N.A	N.A	N.A
	Sub-total (3)	54122.74	N.A	N.A	N.A	N.A
Others	Shifting cultivation	N.A	0.715	0.138	0.005	4.173
	Man-made flooded lands	N.A	0.404	N.A	N.A	N.A
	Sub-total (4)	N.A	1.119	0.138	0.005	4.173
	TOTAL (1+2+3+4)	52919.30	3.064	0.755	0.022	31.331

Source: (2)

Notes: *(1)* *N.A refers to "not applicable".*

(2) *The negative sign (-) stands for "uptake".*

(3) *The positive numbers refer to emissions.*

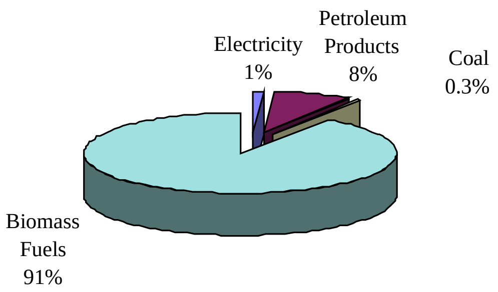
4 The Energy Situation and its Relationship to Forestry

4.1 Energy balance

A country's energy balance shows the amount of energy supplied and consumed during a particular period by a given country. It also displays some energy sources that are used as transformation inputs, for example the production of electricity in Tanzania apart from hydropower diesel is used. The energy balance has been developed using the Long Range Energy Planning (LEAP) model.

The energy balance displays the predominance of biomass based fuels. Like most developing countries in which woodlands and wooden grasslands are the predominant type of vegetation, biomass, particularly woodfuel (charcoal and firewood), is the main source of energy to both rural and urban areas. It accounts for approximately more than 90 % of the primary energy supply. Commercial energy sources, i.e., petroleum and electricity, account for about 8% and 1% respectively of the primary energy used. Coal accounts for less than 1% of the energy used. Nevertheless, Tanzania has a number of other indigenous energy sources including; considerable potentials of hydropower, coal, natural gas, solar, and wind.

Figure 4.1 Energy supply by fuel (1995)



4.2 Energy demand-supply patterns

Although biomass is the main source of energy, Tanzania relies heavily on imported commercial energy in the form of crude oil and petroleum products, characteristic of all non-oil producing economies. Subsequently, most planners have simplified their work by directing their attention on fossil fuels, particularly, petroleum and coal where data is more easily available. Therefore, more research has been on commercial fuels, which dominates the monetized economy and less on the woodfuel or biomass fuels.

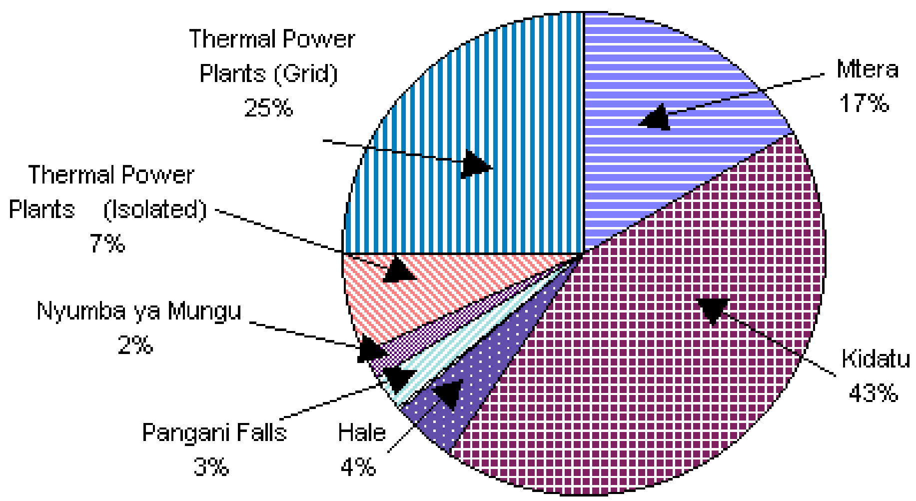
Table 4.1: Energy demand (tonnes of oil equivalent (TOE))

	Household	Agriculture	Industry	Commercial	Transport	Total
Electricity	43.27	0.18	24.27	35.34	0.00	103.05
Gasoline	0.00	0.00	0.00	0.00	141.72	141.72
Kerosene/ Jetfuel	121.61	0.00	2.11	2.43	0.00	126.15
Diesel/Gas oil	0.00	7.15	0.00	0.00	353.91	361.06
Fueloil	0.00	0.42	38.43	0.00	0.00	38.85
LPG/ (Bottled)	1.88	0.00	0.00	2.31	0.00	4.19
Coal	0.00	0.00	22.51	0.00	0.00	22.51
Fuelwood	6774.83	0.00	239.75	28.71	0.00	7043.30
Charcoal	358.72	0.00	29.68	5.69	0.00	394.09
Crop residue	189.17	0.00	0.00	0.00	0.00	189.17
Bagasse	0.00	0.00	1.18	0.00	0.00	1.81
Total	7489.48	7.75	358.56	74.48	495.63	8425.90

Source: (25)

Tanzania's main source for electricity generation is hydro based providing the base load while the thermal plants provides the peaking load. Most urban centres in Tanzania are electrified. However, less than 7 % of the total population has access to electricity. Per capita consumption of electricity is merely 60kWh.

Fig 4.2 Existing electricity generation capacity (Total 570 MW 1994)



Source:(17,12,9)

The power system is made up of isolated plants and the interconnected grid. The bulk of the isolated system consists of thermal power plants powered by reciprocating diesel engines. Total installed capacity of the isolated power plants in 1990 was 32.82 MW generating about 64.3 GWh per year (5). Most of these plants are old and in dire need of spare parts to make them operational.

The grid system comprises hydro and thermal power plants connected to the grid. Thermal power plants connected to the grid have largely been operated as peaking power plants and the hydro power plants providing the base load. In 1990 the total installed thermal capacity was about 120 MW producing about 15.78 GWh(5).

In 1993 two combustion turbines with a rated capacity of 36MW were added to the grid system in order to bridge the growing power shortfall that had resulted from poor hydrological conditions in the Ruaha water basin. It is estimated that the contribution of the thermal power plants in the interconnected grid system will grow with the addition of the natural gas option in the least-cost power-generation expansion programme. Redevelopment of Pangani System was recently completed and adding its capacity to 60 MW.

Tanzania has embarked on development and utilization of natural gas from Songo songo offshore gas fields to generate electricity and other industrial applications. Furthermore, the country is continuing to develop a 180MW-hydropower plant at lower Kihansi to be commissioned in 1999. Nevertheless, with these major undertakings, the majority of the population still continues to rely on biomass-based fuels. The additional capacity will mainly stabilize supply to connected consumers and a few to be connected along with the implementation of the undertakings, considering that extension of the grid to other remote areas is capital intensive and cannot be easily achieved.

In 1993 Tanzania abolished the state monopoly of the power sector. Prior that only a single utility was responsible for developing, generating, and distributing electricity in the country. This prompted the public and the private sector to consider promoting and enhancing development and use of alternative sources to areas not connected to the grid or where they are economically feasible. Recently a Malaysian company Independent Power Tanzania Ltd (IPTL) has started construction of a 100 MW thermal plant at Sala Sala in Dar es Salaam. However, there are issues to be sorted out regarding regulation of independent power producers and appropriate power pricing policies. Therefore if well conceived, the involvement of private sector in power production will increase capacity and raise the level of service. If this is coupled with a sound rural electrification programme, it will somehow reduce pressure on forests for fuelwood search. Rural electrification will go a long way in provision of substitute energy to rural population and therefore provide solution to degradation of forest resources.

4.3 Energy supply from forest resources

Dependence on biomass fuel will continue for many years because of the high cost of developing alternative sources of energy, and the costs to households of the switch to alternative fuels. The long-term effect has been that most regions are faced with serious land degradation, woodfuel scarcity and desertification (10). The welfare of the people of Tanzania depends largely on the sustainable management of its land resources.

In spite of importance of biomass energy, its supply potential, mainly woodfuel is dwindling rapidly creating local energy scarcities and environmental degradation. However, there is a lack of reliable data on the growing stock and the allowable annual cut for woodfuel TFAP estimated the allowable annual cut (mean annual increment) for woodfuel in Tanzania to be around 18 million m^3.

Various woodfuel consumption surveys have been conducted in Tanzania over the last 20 years. There is a considerable variation in the estimates of per capita woodfuel consumption, which ranges from 0.50 m^3 to 2.10m^3. The variation is caused by the abundance or scarcity of woodfuel at local levels and the distances over which woodfuel has to be collected. It is estimated (12) that the average per capita woodfuel consumption for domestic purposes in Tanzania to be around 1.5 m^3.

Based on literature review and field observations, the total woodfuel consumption in 1993 was estimated to be around 38.82 million m^3 of solid wood, as shown in Table 2.13.

Table 4.2 Woodfuel consumption by year 1993 in Tanzania

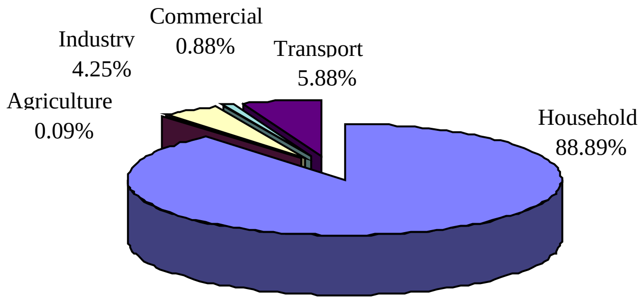
Category of Consumption	Amount Consumed (m^3)
Rural Household	32,100,000
Urban Household	5,400,000
Tobacco Curing	459,800
Salt Production	350,000
Fish Smoking	218,100
Bakeries	150,000
Tea Drying	108,000
Pottery and Ceramics	20,000
Sugar Processing	8,000
Lime Production	4,400
Honey and Beeswax Processing	840
Total	38,819,140

Source: (10)

4.4 Biomass energy use

Energy consumption in the household sector accounts for more than 89% of total energy, most of it being biomass. Biomass energy refers to fuelwood, charcoal, crop residue, and cow dung. The most significant energy end-use in households is cooking. The household sector is divided into urban and rural households because their consumption patterns differ extensively. Although industrial, commercial, transport and agriculture sectors are more important in the economy their share in energy consumption is relatively small, that is 4%, 1%, 6% and 0.1% respectively. Our analysis will relate the household energy activities with the forest resources depletion.

Figure 4.3 Energy Consumption by Sector



5 Policies and Assumptions for the Scenarios

5.1 Main assumptions for the construction of the scenarios

Before embarking to the scenario development the underlying assumptions for the scenarios are outlined. The assumptions for the construction of the are based on the following issues:-

a) Land-use management will consider the need to boost tourism protect watershed forests, and soil erosion in hilly and flood prone areas;

b) Mangrove forests, miombo woodlands and rare species will be protected for some decades before they are harvested at their real market value;

c) More land will be declared forest or game reserves, thus increasing the land area under forest reserves from 13.0 million hectares in 1990 to 15.3 million hectares by year 2020; and

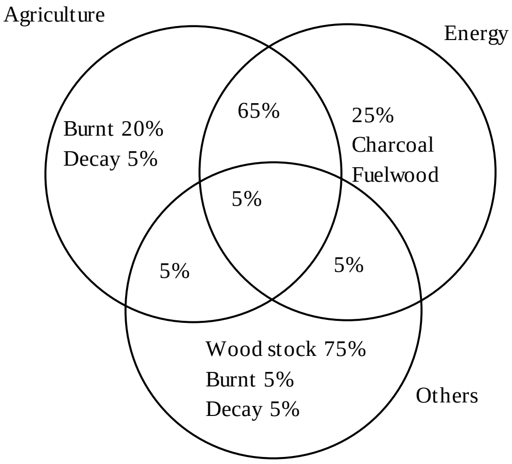
d) Properly managed natural forests have both high atmospheric CO_2 reduction potential, and enormous carbon storage as wood, and thus should be treated as man-made forests.

Performance of the forestry and land use sectors is dependent on economic activity, population growth and land use, forestry, and other relevant environmental policies. GHG emission projections and relevant mitigation options are very much dependent on the above mentioned factors. In order to accommodate these factors the following assumptions have been made a priori:-

- Population increase and deforestation for agriculture activities are directly related;
- Energy intensity and deforestation rate are directly related;
- The need of woodfuel and timber or poles will continue to deplete forests in the vicinities of human settlements and within few kilometres from major roads.
- Economic activities relevant to forestry grow at the same rate as the GDP;
- Energy policy implications has an impact on the mitigation options;
- Excessive harvesting without corresponding planting of trees will continue shrinking the sinks of CO_2; and
- No significant changes between the catastrophic and enhanced TFAP scenarios are expected between the years 1990 and 2000. Therefore the impact of the enhanced TFAP programmes and the mitigation scenario can be observed from year 2000 onwards.

Assuming that deforestation has three agents working at the same time, tree regrowth will not recover the original biomass in a short time, unless the area is left fallow for a long time. Furthermore, the activities are related, whereby logging removes the big trees and then charcoal making uses the remaining branches and agriculture clears the rest. Remains from agricultural clearing are either burnt on site or taken away as fuelwood and others decay on site. Figure 5.1 illustrates the relationship between deforestation activities.

Figure 5.1 Deforestation activities and inherent relationships



5.2 Land policy and legislation

The Land Policy which is still in draft form, aims to promote the best use of land and to make land easily accessible to individuals or to groups for social use or economic development. In the policy, key issues of the existing land tenure system that impede land development are addressed. Furthermore, it sets criteria for land allocation and use based on economic, technical and environmental considerations in order to attract long-term investment or land improvement. The policy sets out a mechanism for solving land conflicts. The main objectives of land sector development are (11):-

(a) to improve the quality of land management services by improving efficiency;

(b) to incorporate conservation measures in land-use plans at all levels;

(c) to ensure that permits, licenses, and claims for land development are issued in line with land-use and environmental protection policies; and

(d) to reduce land conflicts by introduction of buffer zones to separate competing land-uses, especially where agriculture development is in conflict with forestry or rangelands use.

This implies that land and forest ownership rights by individuals or communities should be based on their willingness to invest in land or forest development, conservation or protection. The Land Ordinance (Cap. 113) primarily regulates Land tenure in Tanzania. This Ordinance is outdated and cannot address most of environmental issues that are characterized by mounting pressure on land (11).

5.3 Forestry policies and legislation

The main forestry policy objectives include (11):

(i) demarcation of sufficient forest land for the country's economy needs,

(ii) management of the forest resources on public lands in sustainable manner;

(iii) encouragement of and promotion of good forestry practices;

(iv) undertaking of scientific research; and

(v) strengthening grassroots forestry education.

The current forestry policy is out-of-date. It is now under review with the major policy change being aimed at proper management of the forestland and resources for sustainable development (11).

The review of the policy will centre on the following elements:

(a) managing forest resources for sustainable development;

(b) involving local government bodies, private individuals and private enterprises in various forest based activities by rationalizing institutional framework of the forest sector and enhancing the supportive role of government to the forest based activities; and

(c) intensification of efforts to conserve the country's ecosystem by carrying out inventories of all ecosystems in order to develop a sustainable management plans for these areas.

The Forest Ordinance (Cap. 389) is the main legal instrument of the Forestry Policy implementation.

Forests are among the most natural assets of many countries of the world. This is mainly attributed to their prospective aspects of wildlife, water and soil conservation, amelioration of climate, amenity and recreation. In many areas including Tanzania, forests and trees are the critical elements, which make the very existence of human and animal life possible. The benefits accruing to the society in return for investment in forest conservation include photosynthetic fixation of solar energy, maintenance of water cycles, regulation of climate at macro and micro-levels, influencing temperature, precipitation, and winds. They are also an important source of wood and non-wood products, which are of great social and economic importance to most of our countries.

Since the enhanced TFAP scenario depicts the national plans and programmes, the TFAP is an important input. The TFAP was developed by the Ministry of Natural Resources and Tourism in 1989 to map the development of the sector for the period 1989-2008. However since our analysis has to cover the period 1990-2020 we will use the TFAP projections up to year 2008 and then extrapolate it to year 2020. It is also assumed that under this scenario all related policies and programmes will be implemented. Therefore, before making the projections it is important to make an overview of various aspects related to forestry and land use which are going to impact on the enhanced TFAP and mitigation scenarios. These aspects include the land tenure policy and its current review, Population policy, Urbanisation, National Environment Policy, and National Energy Policy.

5.4 Land tenure policy and legislation

The existing legislation on land tenure and administration is being updated/revised to meet the current developmental needs and mitigate existing conflicts related to land matters. The revised legislation and policies are expected to create a long-term ownership vision so as to provide farmers with incentive to improve the land through labour and investment. It will further encourage land conservation and protection against land degradation, which will have an influence in the enhanced TFAP as well as mitigation scenarios.

The new policy and legislation also take care of "public lands", which is unallocated land between villages, or "any land which is not occupied", so as to avoid encroachment of forests which are in such lands. Furthermore, proper management of these lands is to be assured. The enhanced TFAP scenario assumes that the accessible forests and these public lands will continue to be utilised but the tree planting programmes in the TFAP programmes will to a large extent mitigate these effects.

5.5 Population policy, urbanisation and its impacts

Tanzania adopted the National Population Policy (NPP) in 1992. The policy recognises that there is no simple cause and effect relationship between population growth and economic growth, and that population growth may not be the primary obstacle to development. Nevertheless the NPP realised that population growth aggravates the difficult economic situation and renders remedial measures more difficult. At the macro level rapid population growth tends to increase outlays on private and public consumption, drawing resources away from savings for productive investment.

The NPP recognises also the impact of population growth on natural resources and the environment. It is recognised due to rapid population growth and increased number of livestock there has been an increase in pressure on natural resources, leading to their over-utilization and degradation. The policy also realizes that higher demand on the environment are made by food requirements for wildlife and fisheries; housing for the increasing population; and requirements for the recreational amenities.

The NPP spells out as its principal objective, to reinforce national development through developing available resources in order to improve the quality of life of the people; with special emphasis laid on regulating population growth rate, enhancing population quality, and improving the health and welfare of women and children. The NPP is intended to provide guidelines that would strengthen the process of integrating and thus providing means at all times of monitoring and evaluating national development plans more accurately.

Other NPP goals, which should be emphasized during preparation of development plans, include among others, to promote sustainable relationship between population, resources and environment. Furthermore, it intends to promote a more harmonious relationship between rural, urban and rural development in order to achieve a spatial distribution of the population conducive to the optimal utilization of the nation's resources.

The NPP is intended to be comprehensive, as population, like environment, is a cross-sectoral issue. The issues addressed include population growth and health; population growth and nutrition; the impact of population growth on natural resources and environment; population growth and employment; gender, and the problems of children, the youth, people with disability and the elderly. Institutional building, advocacy and population education in form of information, education and communication (IEC) are the main NPP implementation strategies.

5.5.1 Population distribution

Population distribution is the spread of people within an area available to them for exploitation. The 28.9 million people living in Tanzania in 1995 occupied a total land of 885,987 square kilometres.

Table 5.1 Regional cumulative percentage of population and land area distribution and density 1995.

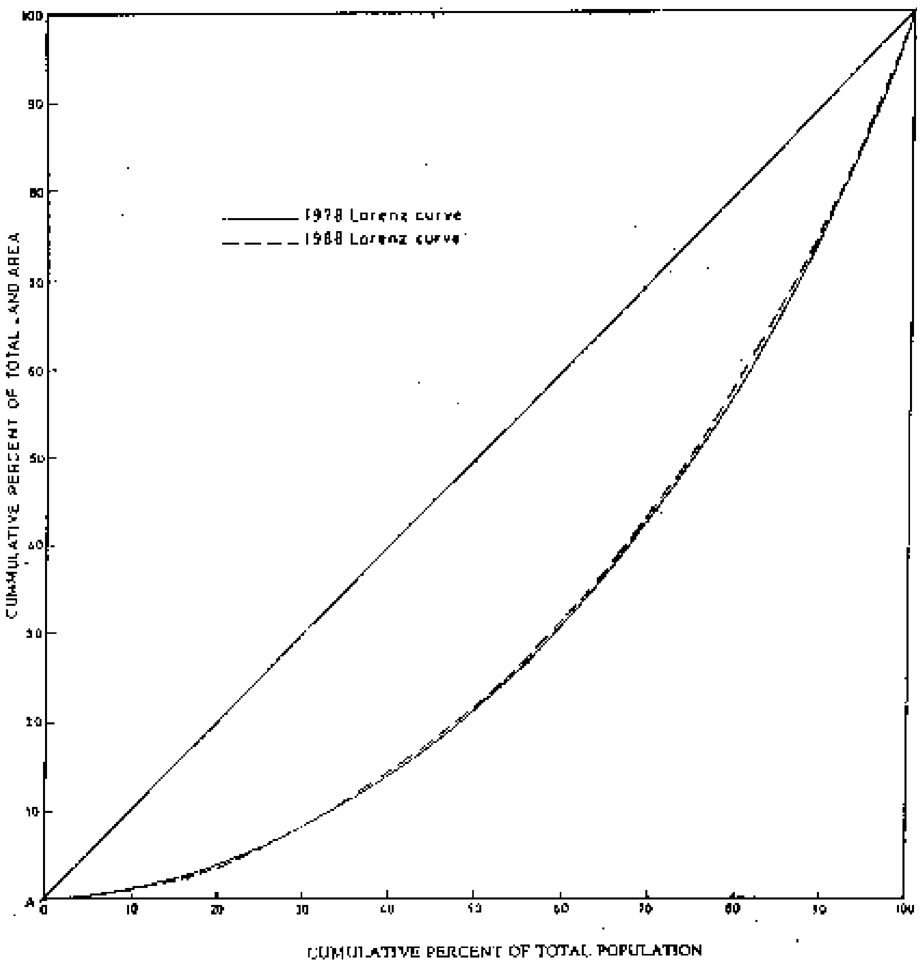
Region	Cumulative % pop 1995	Cumulative % land	Density
Dar	6.70	0.2	1357.5
Zanzibar	9.52	0.5	323.6
Mwanza	17.49	2.7	114.4
Kilimanjaro	22.03	4.2	96.7
Mtwara	25.49	6.1	58.6
Kagera	36.37	12.3	55.8
Tanga	30.75	9.1	55.6
Mara	40.50	14.8	53.6
S'nyanga	48.15	20.5	42.6
Dodoma	53.33	25.2	35.4
Mbeya	59.82	32.0	30.4
Kigoma	63.47	36.2	27.8
Iringa	68.58	42.6	25.4
Coast	71.20	46.3	22.8
Morogoro	76.64	54.3	21.7
Arusha	82.84	63.6	21.3
Singida	86.19	69.2	19.2
Tabora	90.56	77.8	16.2
Ruvuma	94.04	85.0	15.4
Rukwa	97.38	92.6	13.8
Lindi	100.00	100.0	11.2
Tanzania		_	31.9

Table 5.1 shows a relatively unevenly distributed population over the land area, with about 54 percent of the total population occupying 25 per cent of total land. This is clearly demonstrated by the Lorenz curve (Fig. 5.2) which shows the cumulative percent contribution of the regions to the total land area and total population. The further the curve deviate from the diagonal line, the higher the unevenness of the population distribution.

Analysis of the population distribution at the district level demonstrates an even more variation with high concentration of the population in some district and wards. Such analysis indicates that about 65 per cent of the total population occupies only 29 per cent of the total land area.

Though there are tendencies of the population to spread with time and thus becoming more evenly distributed, still population distribution is concentrated in the traditional areas, namely districts in the Lake Victoria Zone, the Northern Highlands, the Southern Highlands, and some parts of the coast area and Southern regions. Most of these districts are areas with high agricultural potential and/or linked to major urban centres.

Fig. 5.2 Lorenz curve of the population distribution and land



5.5.2 Rural-urban population distribution

The majority of people in Tanzania still live in the rural areas (about 80 percent of the total population). As noted above, the availability of arable land and its quality is of considerable importance in explaining the internal distribution of the population.

Population in the rural areas has been decreasing over time. Before independence, the proportion was 97% in 1965, 86% in 1978 and 78% in 1988. It is anticipated that the rural population will continue declining. The urban population however, is increasing very rapidly. Urban population increased by 1,653,305 i.e. by more than 200 percent between 1967 and 1978 while during the following ten years the it increased by 2473067, a more than 100 per cent increase. This population shift is due to employment and other opportunities available in urban areas. The population distribution in rural and urban areas plays a critical role in the country's development beyond the year 2000.

Table 5.2 Tanzania's urban population trend

Year	Population	Percentage of total population
1967	763435	6.2
1978	2416740	13.8
1988	4889807	21.1

The City of Dar es Salaam continues to have the largest proportion of the urban population with a 29.8 percent share. All other regions contributed less than 10 percent to the total urban population. Dar es Salaam region has the largest proportion of urban population (about 90 percent). Other regions, which have high proportion of urban population, include Zanzibar (31.8 percent), and Morogoro (21 percent). The rest of the regions have less than 20 percent of the population living in towns.

Table 5.3 Long-term population forecasts for Tanzania (in Million Inhabitants)

	1990	**2000**	**2010**	**2020**
Rural Population	20.93	27.94	37.29	49.77
Urban Population	4.74	5.90	7.36	9.16
Total	25.67	33.84	44.65	58.93

Source: (22)

5.6 Environmental policies and legislation

Although the existing general policies and many sectoral policies have given some attention to environmental issues, not all issues have been dealt with. This has necessitated the need for Environmental Policy in Tanzania. Specifically four basic considerations have verified the need for a policy on Environment in the Country. These are:- The need to balance the accelerated economic growth with more efficient and sustainable use of the environment and natural resources in the country; The need for environmental management consideration to be integrated in all sectoral areas of policy and action; The interconnectedness of the environment means that multi-sectoral approaches are vital; and the need for new forms of co-operation among governments, non government organisations, private sector and local communities including an expanded role for women.

The National Environmental Policy which is in the final stages thus seeks to provide the framework for making fundamental changes that are needed to bring environmental considerations into the mainstream of decision making in Tanzania. It seeks to provide policy guidelines, plans and gives guidance to the determination of priority actions and provides for monitoring and regular review of policies, plans and programmes. It further provides for sectoral and cross-sectoral policy analysis in order to achieve compatibility among sectors and interest groups and exploit synergies among them.

The overall objectives of the National Environmental Policy are therefore:- to ensure sustainable and equitable use of resources for meeting the basic needs of the present and future generations without degrading the environment or risking health or safety; to prevent and control degradation of land, water, vegetation, and air which constitute our life support systems; to conserve and enhance our natural and man-made heritage, including the biological diversity of the unique ecosystems of Tanzania; to improve the condition and productivity of degraded areas including rural and urban settlements in order that all Tanzanians may live in safe, healthful, productive and aesthetically pleasing surroundings; to raise public awareness and understanding of the essential linkages between environment and development and to promote individual and community participation in environmental action; and to promote international co-operation on the environment agenda, and expand our participation and contribution to relevant bilateral, sub regional, regional, and global organisations and programs, including implementation of conventions.

The role of Environmental policy lies in providing for the execution of a range of strategic functions, notably:- The development of consensus agreement at all levels for the challenge of making trade-offs and the right choices between immediate economic benefits to meet short-term and urgent development needs, and log-term sustainability benefits; development of a unifying set of principles and objectives for integrated multisectoral approaches necessary in addressing the totality of the environment; fostering Government-wide commitment to the integration of environmental concerns in the sectoral policies, strategies and investment decisions, and to the development and use of relevant policy instruments which can do the most to achieve this objective; and, creating the context for planning and coordination at a multisectoral level, to ensure a more systematic approach, focus and consistency, for the ever-increasing variety of players and intensity of environmental activity.

5.6.1 The National Environmental Action Plan

Since environmental policy involves many sectors and interest groups its scope is necessarily broad, and the logistical demand for overseeing its implementation and ensuring coordinated attention to interconnected challenges is complex. The challenge is to ensure that all concerned take priority actions on all the main fronts; and that their actions are mutually supportive, toward a common goal. This means that the environment must be subjected to greater accountability and control, with more effective instruments having clear objectives to be pursued.

The National Environmental Action Plan (NEAP) is Tanzania's first step towards a comprehensive incorporation of environmental concerns into the fabric of national planning development. The NEAP is the translation of the National Environmental Policy in to actions. The importance of this step is the fact that most Tanzanians depend on the natural resources and resources of the country for their livelihood and future generation will need those resources for their well being. The national environmental policy sets out the urgent need for creation of a new cross-sectoral framework to address the complexity of the identified environmental problems. The action plan creates an ongoing agenda to address the identified environmental problems, which are cumulative results of actions and processes taking place over a long time.

The action plan, among others, seeks to; intensification of a national environmental education and public awareness including the continued involvement of stockholders in all environmental management aspects; the integration of the national environmental policy and conservation strategy into the country's national planning and programming; research and technology initiatives to better understand the priority issues; strengthening of a national Environmental Information system; the performance of EIA on selected projects and incorporation of the environmental assessment approach into all aspects of planning and decision making; establishment of an overall legislative framework and effective sectoral legislation pertaining to the environment and preparation of priority long term investment programs based on a national program oriented approach to complement the existing development plan in order to address major environmental problems.

The status of the implementation of NEAP is encouraging. Consultations among the relevant key ministries has been finalized and plans are underway to start on the consultations among other stakeholders for the implementation of NEAP including CBOs, NGOs and Local authorities within each region.

5.6.2 The National Environmental Legislation

The Division of Environment undertook compilation and evaluation of sectoral environmental laws. A National Workshop on the formulation of a framework Environmental Legislation and review of sectoral laws was held in September 1995. The document of workshop proceedings has been prepared, as well as a project proposal for the formulation of a framework environmental legislation and review of sectoral laws. Efforts are underway to secure funds from UNEP to support preparation process for the formulation of a framework environmental law and review of sectoral laws relating to the environment.

5.7 National Energy Policy

In 1992 the government launched the National Energy Policy with the following objectives:-

(a) establishing an efficient energy production, procurement, transportation, distribution, and end-use system in an environmentally sound manner and with due regard to gender issues,

(b) reducing the use of petroleum based products for transport and the industry sectors by harvesting indigenous energy resources,

(c) directing the policy towards

- exploitation of the abundant hydro-electric resources
- development and utilization of natural gas resources
- development and utilization of the coal resources
- increased petroleum exploration activities
- arresting woodfuel depletion by evolving more appropriate land management practices and more efficient woodfuel technologies
- development and utilization of forest and agricultural residue for power and cooking energy production
- minimization of energy price fluctuations
- development of human resources for development of energy technologies
- ensuring the continuity and security of energy supplies

6 The ‘Catastrophic Scenario’

6.1 Definition of the Catastrophic Scenario

In greenhouse gas mitigation analysis, it has always been assumed that the baseline scenarios are consistent with national plans and programmes. However, in forest and land use sectors policies and programmes do exist, which forms the baseline, but due to various problems, they are not implemented. Therefore, in our analysis instead of having two path, the baseline situation and mitigation situation, there is a situation whereby the baseline path is not implemented. This path is hereby named the “catastrophic” scenario, which is an inconsistent one and a business as usual trend, is experienced. Under this scenario it is assumed that programmes in the forestry and land use sectors envisaged in the relevant policies are not implemented or are implemented in pieces. This may be due to various problems encountering the country including the following:-

- lack of financial resources to implement the programmes;
- lack of awareness on the part of stakeholders;
- incompatibility of other sector policies and programmes which relate to forestry and land use;
- less priority accorded by policy makers;

6.2 Main assumptions underlying the Catastrophic Scenario

The catastrophic scenario assumes that the current deforestation rates persist and very little is done to redress the situation. Unsustainable harnessing of natural resources continues due to poverty and population pressure, and very little is done to intervene. Although literature put deforestation at between 300 to 749 kha per annum we use adjusted figures for the GHG emission used in the inventory. The adjustment were necessary because if such figures are used there will be no tree left in the country by the year 2000. We adjust for factors such as accessibility of the forests, whereby forests, which are very far from the road, are left untouched due to transportation problems. Therefore deforestation is limited to areas near roads and railways, and near settlements.

The following assumptions are therefore made:-

- Deforestation and emissions due to agriculture will continue to be influenced by population pressure and therefore its growth will be 2.8%;
- Deforestation and associated emissions due to other economic activities like timber and

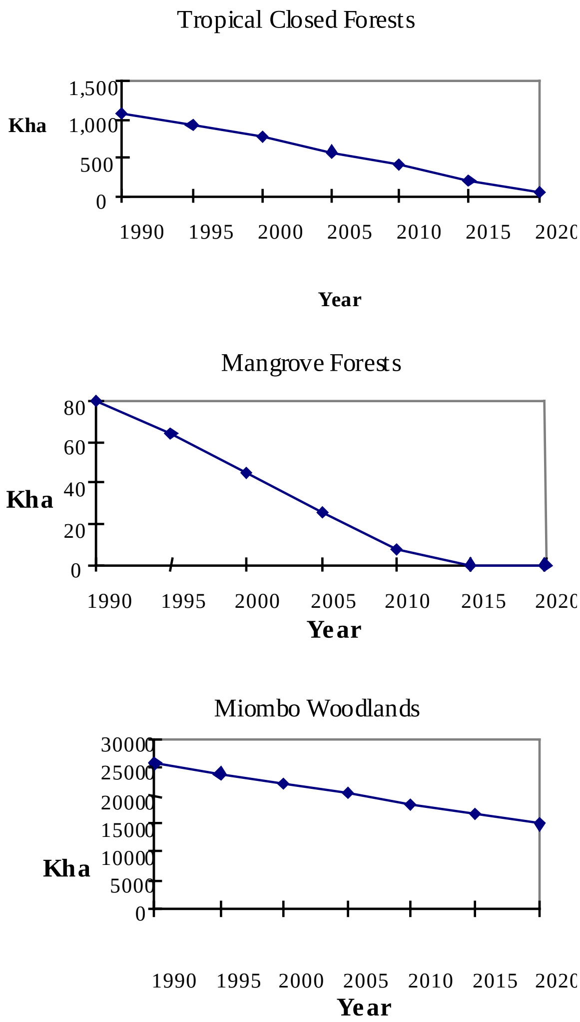
poles will be influenced by economic growth and therefore will grow at 5%;

- Inaccessible forests continues to operate the closed carbon cycle and therefore are not considered here; and
- CO_2 emissions and sequestration is therefore associated with dynamic activities of tree cutting/harvesting and regrowth/planting.

6.3 Forestry and land-use situation under the Catastrophic Scenario

Forests that are accessible to human activities will suffer severely under the catastrophic scenario. Therefore, the tropical closed forests and mangrove forests, which in most cases in Tanzania are located within reach of neighbouring inhabitant, are in a danger of being depleted. The miombo woodlands have an advantage of a big part of it being inaccessible. Figure 6.1 shows the behaviour of the forestry sector under this scenario.

Figure 6.1 Deforestation trend for the catastrophic scenario



6.4 Greenhouse gas emissions under the Catastrophic Scenario

Due to unsustainable nature of development in this scenario, an increasing trend of GHG emissions from land use and forestry is experienced. Furthermore, the sinks are depleted hence diminishing uptake from the accessible forests and plantations.

Normally CO_2 emissions from fuelwood consumption are accounted for in the forest sector during clearing of the trees. Other gases are accounted for in the energy sector. However, in this case emissions from fuelwood are accounted for in the energy sector, and specifically the household and commercial sectors' energy use. Table 6.1 shows CO_2 emissions under the catastrophic scenario.

Table 6.1 Projected carbon dioxide emissions and removals by land-use and forestry under catastrophic scenario

	1990	1995	2000	2005	2010	2015	2020
Forest conversion for agriculture	727	835	958	1,100	1,263	1,450	1,665
Grassland conversion for agriculture	15,375	17,651	20,265	23,265	26,710	30,665	35,205
Forest Exploitation for Fuelwood	40,563	46,568	53,463	61,379	70,467	80,901	92,879
Abandoned managed land	-1,931	-1,675	-1,453	-1,261	-1,094	-949	-823
Uptake by plantation forests	-1,351	-1,172	-1,017	-883	-766	-664	-576
Natural forests subject to human activity	-364	-316	-274	-238	-206	-179	-155
Village woodlot, and urban tree planting	-99	-86	-75	-65	-56	-49	-42
Total (Gg CO_2)	52,919	61,805	71,867	83,299	96,318	111,175	128,152

Under the catastrophic scenario net CO_2 emissions almost trebles, mainly due to extensive land clearing for agriculture and unsustainable harvesting of forests, which shrinks the sinks to less than one fifth. The situation is expected to worsen due to the fact that out of every 20 hectares of forests that are clearfelled, only one hectare is planted.

7 The 'Enhanced TFAP' Scenario

The enhanced TFAP scenario development is based on the existing national development plans including the Tanzania Forestry Action Plan (TFAP) (10) and projections based on Forest Management Plans. Since TFAP target is the year 2008, implementation beyond the year 2008 is extrapolated on the basis of these programmes and projects.

7.1 Programmes and projects under the enhanced TFAP scenario

Programmes and projects under the enhanced TFAP scenario can be grouped into four. These are the Land husbandry programme, Forest management Programme, Forest Industries programme and Bioenergy Programme. Tables 7.1 (a) to 7.1 (d) shows the relevant projects and programmes for the enhanced TFAP scenario.

7.1.1 Land husbandry

Land husbandry involves all activities related to sustainable utilisation of the land for various uses. These include agroforestry, maintenance of catchment forests, and sustainable woodfuel harvesting.

These projects are implemented under the TFAP whereby land husbandry activities are as shown in Table 7.1 (a). These activities include village forestry programmes whereby afforestation programmes, agroforestry and community forest for fuelwood will be carried out. Under the forests for fuelwood programme, it is envisaged to plant 8000ha of forests in peri-urban areas of various cities in Tanzania to enhance subsistence fuelwood business for these villages. The TFAP indicates that the 8000ha will be planted for 20 years from 1988 to 2008. Using expert judgement it means 400 ha per year will be planted. This figure is used to extrapolate the number of hectares covered to the year 2020.

Table 7.1(a) Programmes and projects under the enhanced TFAP scenario (land husbandry)

Project title	Location	Activities	Land/Material input	Financial input (Mill. US$)
District level sustainable land husbandry Improvement in potential areas	Mbeya and Rungwe districts in Mbeya region	• Farm level tree planting and soil conservation • Mixed cropping • Catchment forest rehabilitation • Establishment of village level nurseries • Training	15,000ha.	7.17
Community and Farm Forestry in high potential areas	Mbeya, Arusha, Kagera, Iringa, Kigoma, Ruvma, and Kilimanjaro regions	• Training of staff, farmers and other beneficiaries incl. Self help groups • decentralised nursery establishment • tree planting in about 20-25 villages in each region • establishment of communal woodlot on communal land • soil conservation and catchment forest rehabilitation		1.33
Semi-arid zone village forestry programme: afforestation training and extension	Same district in Kilimanjaro region	• Trial forest plantation and • management of existing forests • seedling production and distribution • training and extension services		9.69
Village woodland management programme: Conservation of woodland and production of woodfuel and timber	Mtwara, Lindi, Coast, Tanga and Morogoro	• Planning and management of integrated land use in villages and farms • Conservation of agricultural land, catchment areas • management of natural forests • multi purpose tree planting by villages and farmers • improvement of charcoal making • establishment of small scale wood-based industries and beekeeping • training		3.33
Village woodfuel production for urban markets	Villages in peri urban areas of Dar es Salaam, Mwanza, Dodoma, Morogoro, Arusha and Iringa regions	• Selection of four pilot villages in each region • preparation of energy focused land-use investment projects • Design, development and implementation of appropriate technology • training		1.33
Peri-urban and village forest plantation for woodfuel production for urban markets	Dar es Salaam Mwanza, Arusha	• go grow 4,200 ha at Ruvu for Dar es Salaam, 2,300 ha for Mwanza/Shinyanga and 1,500 ha for Arusha	8,000ha	9.8
total				32.65

7.1.2 Forest management

Activities in forest management programmes include protection and rehabilitation of the existing forests, as well as controlling them in the form of sustainable harvesting. Projects under this programme include gazetting of new forest reserves, management of the miombo forests, hardwood plantation in closed broadleaf forests and management of plantation forests including the Sao hill softwood forest. This programme is expected to cost US$ 33.33 million. Table 7.1 (b) shows in detail the projects involved in the forest management programme.

Table 7.1(b) Programmes and projects under the enhanced TFAP scenario (Forest Management)

Project title	Location	Activities	Land/Material input	Costs (Mill. US$)
East Usambara Catchment Forest	Muheza and Korogwe districts in Tanga region	• Support to existing plantation experiments • Control of encroachment • Management of park/nature reserves	7,7000ha.	2.42
Mount Kilimanjaro Catchment	Mount Kilimanjaro	• Management of forest reserve • Planting trees around boundaries 70km • controlling of harvesting	165,600 ha.	0.34
North and South Uluguru Forest	Uluguru Mountains	• Intensification of boundary cleaning and tree planting along the boundary estimated at 400km • planting of trees in open areas of about 120ha • Controlling harvesting	120ha	0.39
Miombo Forest Development	Tabora region	• Semi intensive management of 50,000ha per annum starting in 1991. • Target at managing 1 mill. Ha. By year 2008. • To start with Nyahua Mbuga (680,000ha) then Itulu Hill (380,000ha) • To include the whole miombo of Tabora region	1,000,000ha	2.64
Mangrove Forest Development	Coastal Region	• Augmenting current efforts in management and conservation • Put the whole mangrove area under proper management • Control harvesting • extension services to local users on proper harvesting and utilization methods to safeguard regeneration and make efficient use of mangrove products	120,000ha.	0.51
Gazetting of new forest reserves	Ruvuma, Mtwara, Lindi, Coast, Rukwa, Kigoma	• Forest division target gazetting total of 3.8 mill. ha. By gazetting 200,000 ha. annually • District councils target of total of 2 mill. ha. at 100,000 ha. per annum • Village governments target of 950,000 ha. at 50,000 ha. per annum. • reserve these forests by demarcation of boundaries, screening of firelines, controlled burning and harvesting.	6,750,000ha.	4.76
Industrial hardwood plantation development	Tanga, Iringa, Morogoro, Mbeya	• Production of seedlings • establishment of seed stands and sales of seeds and seedlings • involvement of villages, farmers and landowners in the planting programme • provision of technical assistance • plantation establishment on government, village and private land and subsequent silvicultural treatment and harvesting		1.77
Sao Hill Forestry (Phase III)	Sao Hill, Mufindi District, Iringa Region	• Identification of suitable wood industries • Inventorying of the Sao Hill forest resources • Development of comprehensive management plans • Increasing the plantation area to 60,000ha.	60,000ha.	20.5
Total			8,172,720 ha	33.33

7.1.3 Forest Industries Programme

Only 50% of the Tanzanian forest industry capacity is being utilized. Harvesting of hardwood sawlogs has concentrated on a relatively few important and well-known species. Logging has been very intensive near larger sawmills and hardly any harvesting is carried out in areas lacking roads and wood industries. The industrial plantations suffer from a discrepancy between production possibilities and inadequate felling due to lack of industrial capacity.

The TFAP target is to ensure solution to the above problems through the following:

- utilization of wood resources with less waste;
- where applicable, substitution of hardwood by softwood;
- more emphasis to be given to utilisation of lesser-known hardwood species; and
- utilization of surplus softwood through new investment in industry capacity.

In order to reach the above targets the TFAP proposes the projects and programmes as shown in Table 7.1 (c).

Table 7.1(c) Programmes and projects under the enhanced TFAP scenario (forest industries)

Project title	Location	Activities	Land/Material input	Costs (Mill. US$)
Plantation based sawmilling	Mwanza, Dodoma, Morogoro, Mbeya, Kagera, Lindi, Mtwara, Ruvuma	• Carry out feasibility studies and financing proposals • procure and install equipment and machinery • training		0.83
Rehabilitation and improvement of Mpingo based industries and marketing	Mtwara, Lindi, Morogoro, Coast regions	• Mpingo Sawmill log transport upgrading • Mpingo sawmill equipment upgrading • Small log sawmill recovery improvement • Mpingo by products conversion • offcuts marketing of mpingo for export • improvement of mpingo merchants' selling facilities • Strengthening the traditional mpingo carvers' cooperative and informal working groups of artisans		0.76
Mobile sawmills	Rubya, Longuza, Ukaguru, Rondo, Ruhindi, Rubare, Matongoro	• Assessment of entrepreneurial capacity of potential investors • Procurement and establishment of equipment for sawmills and logging • Training the small staff needed • Financing and market arrangements		0.19
Improvement of pitsawing, carpentry and small-scale furniture making	Mbeya, Ruvuma, Dar es Salaam, Tabora regions	• Survey of pit sawing, carpentry and furniture making in respect of employment, production technology, skills etc • Design and launching of action programme for the promotion of the sector • Improvement of standards, improved tools training and extension services		1.00
				2.78

7.1.4 TFAP targets for energy from forest resources (bioenergy)

In recognition of the importance of biomass energy in the economy, the government has given it a priority in its energy policy with the objectives of improving the welfare of the people by reducing the financial and labour costs of meeting their basic energy needs. The policy also aims at reducing destructive impacts of wood energy demand on forests and other land use systems.

Strategies to achieve the above policy objectives include:-

- the increase of local wood supplies by various form of afforestation;
- reduction of wood energy needs through greater efficiencies of wood energy conversion and utilisation;
- substitution of woodfuels by alternative energy sources;

The TFAP recognises the very different wood energy situations presented by rural and urban populations, by the poor and the better off and the need to plan for rapid population growth, especially in urban centres. It also recognises the importance of firewood and charcoal production for urban markets as a source of rural cash incomes. Table 7.1 (d) shows projects and programmes to achieve the above objectives.

Table 7.1(d) Programmes and projects under the enhanced TFAP scenario (bioenergy)

Project title	Location	Activities	Land/Material input	Costs (Mill. US$)
Dissemination of efficient woodfuel conversion and utilization technologies	Major Urban Centres including Dodoma, Mwanza, Arusha, Moshi	• Dissemination of improved household and institutional charcoal stoves and wood stoves • Training in efficient management of traditional earth mound and pit charcoal kilns and dissemination of casamance and brick charcoal kilns • identification of private sector charcoal producers and stove manufacturers and provide technical assistance • provision of repayable grants for building and equipment as required		3.0
Programme of wood saving in agro processing, rural industries and institutions	Tabora, Mbeya, Iringa, Lake zone, the Coast Region	• Dissemination of energy saving methods for tobacco curing, • search for and economic analysis of wood saving alternative technologies and their dissemination via manuals, training courses and the media		0.55
				3.55

7.2 Forestry and land-use situation under the enhanced TFAP scenario

The TFAP targets include a reorientation in forest policy from emphasis on the control of forest estates to the promotion of forestry on communal private lands. The reservation will however, continue in lightly populated regions such as Coast, Kigoma, Lindi, Mtwara, Rukwa and Ruvuma. In districts where there are extensive forests, the target is to establish new Local Government Authority reserves. Expansion of tree planting by individuals or groups through extension and training and use of decentralised nurseries as opposed to the existing centralised ones are among the strategies for achieving the TFAP targets. It also aims at conservation of grazing lands, particularly in areas with high concentration of livestock, through such practices as zero-grazing and fodder production and designation of suitable areas as grazing lands. All these will be achieved through peoples/community participation.

In order to ensure sustainable wood supply the TFAP aims at sustainable forest management by involving forest industry in tree planting, harvesting and forest management. Private sector participation is crucial in this endeavour, and the government will gain from the payment of royalties paid by the private contractors. Table 7.2 shows the projections of the amount of land involved under the forest management scheme under the enhanced TFAP scenario.

It should be noted that these accessible forests are the ones that are sources of greenhouse gases emissions due to human activities. Those forests that are not subject to human activities may not be the source of GHGs since they are a carbon stock and activities going on there is just the natural carbon cycle. A net GHG emission will therefore result from an unsustainable use of the forest resources resulting into its depletion.

Table 7.2 Forest management under enhanced TFAP scenario (kha)

	1,990	1,995	2,000	2,005	2,008	2,010	2,015	2,020
Miombo Management	60	548	1,012	1,442	1,700	1,700	1,700	1,700
Miombo and Broadleaf reserve	350	2,100	3,870	5,670	6,750	6,750	6,750	6,750
Mangrove Forests Reserve	80	115	120	120	120	120	120	120
Village woodlot and Urban Tree Planting	24	27	35	49	58	64	78	86
Plantation forests	80	88	97	107	118	130	144	158
Industrial Plantation	1	8	15	22	26	29	35	39

Note: The 1990 and 2008 figures are the actual TFAP projections. The 1995 to 2005 are interpolations from the TFAP while the 2010 to 2020 are projections on the basis of TFAP growth rates. Plantation forests are adopted from the inventory and represents both hardwood and softwood forests, which are not under the industrial plantations. These expand at the rate of 5% linked to economic growth.

7.3 GHG emissions from enhanced TFAP Scenario

Estimation of greenhouse gas emissions resulting from the enhanced TFAP scenario has been made on the basis of illustration in Fig. 5.1, and the same assumptions as in the ‘catastrophic’ scenario. However, in the enhanced TFAP scenario it is further assumed that the proposed policies and programmes are implemented.

It can be noted that some of the activities in the enhanced TFAP scenario are in themselves mitigation options. However, they will be magnified in the mitigation scenario.

In the greenhouse gas inventory the forest and land use sector combine the land use and the bioenergy activities in estimating carbon dioxide emission. Therefore in order to avoid double counting this system has been maintained. However, other gases have been analysed on the basis of devices to enable evaluation of the impact of technology in reducing the emissions.

7.3.1 GHG emissions from land-use changes

Emissions in the land use changes assumes that the rate of increase of forest management activities and related tree growing activities will have the following effects:-

- increase sequestration at the same rate; and
- decrease of emissions from land use changes at the same rate.

GHG emissions from this scenario will therefore be as shown in Table 7.3.

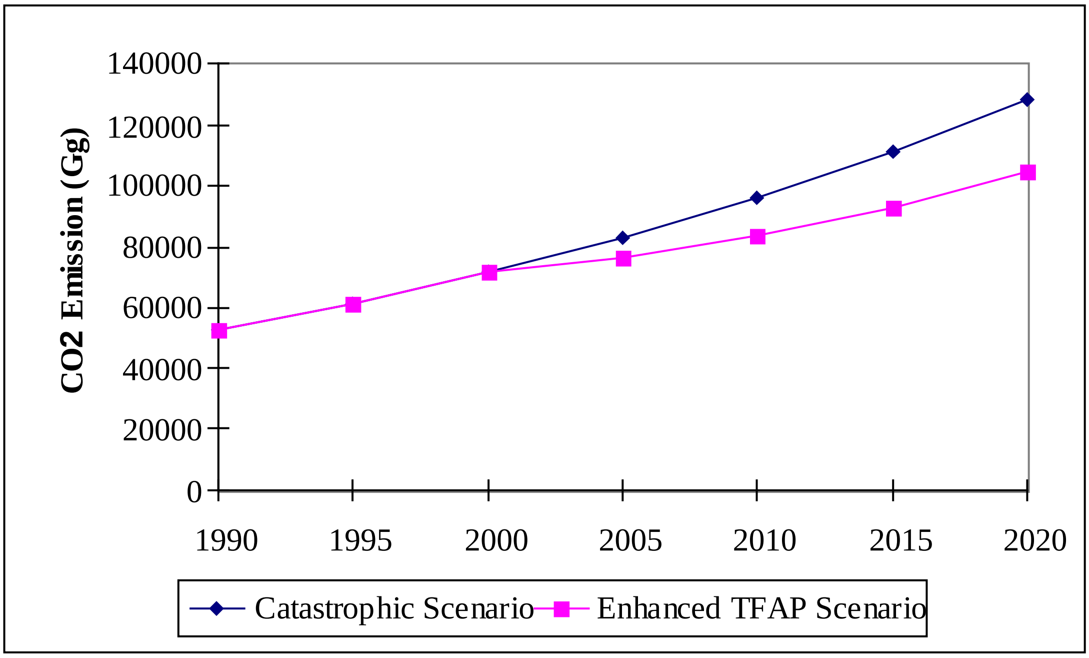
Table 7.3 Emissions and sequestration from the enhanced TFAP scenario (Gg CO_2)

	1990	1995	2000	2005	2010	2015	2020
Forest conversion for agriculture	727	835	958	1,012	1,104	1,217	1,369
Grassland conversion for agriculture	15,375	17,651	20,265	21,404	23,345	25,729	28,948
Forest exploitation for fuelwood	40,563	46,568	53,463	56,469	61,588	67,879	76,371
Abandoned managed land	-1,931	-1,675	-1,453	-1,362	-1,241	-1,119	-991
Uptake by plantation forests	-1,351	-1,172	-1,017	-953	-868	-784	-693
Natural forests subject to human activity	-364	-316	-274	-257	-234	-211	-187
Village woodlot, and urban tree planting	-99	-86	-75	-70	-64	-57	-51
Total (Gg CO_2)	52,919	61,805	71,867	76,244	83,630	92,653	104,766

The enhanced TFAP scenario will have little impact on emissions for the years 1990-2000 because it is assumed that the catastrophic scenario features are dominating. After all only one year is left between now and the year 2000 and the situation now is that the catastrophic scenario features are predominant. Some changes are seen between year 2000 and 2015 and

2020, where due to increased sequestration resulting from tree planting and forest conservation in forest management programmes. Furthermore, less emission at a lesser pace is experienced due to the forest management programme, particularly sustainable harvesting of forestry resources.

Figure 7.1 Comparison of emissions between the Catastrophic and Enhanced TFAP Scenarios



8 The Mitigation Scenario

8.1 Overview of the forestry mitigation scenario

Policy and other measures in Tanzania, necessary to mitigate environmental deterioration through the forest protection and conservation, which also have greenhouse gas sequestration effects include the following:(3):

i) Introducing forest property rights, introducing bank credits of soft lending terms

ii) Diversifying energy sources;

iii) Encouraging the use of appropriate technologies;

iv) Conserving biodiversity;

v) Sharing of tangible benefits from the protected and conserved areas with surrounding population

vi) Use of by-laws in controlling the cutting of wood, overgrazing, wildfire, and misuse of land;

vii) Reserving of some district areas for forestry development;

viii) Declaring all catchment areas to be forest reserves;

ix) Promoting forestry extension services;

x) Controlling the export of rare tree species;

xi) Carrying out research and studies on forestry and biodiversity;

The end use measures include the following:-

(i) Increased efficiency in product utilisation especially timber products;

(ii) Increased efficiency in production and utilisation of bio-energy;

(iii) Improved technologies in the end use devices (e.g., improved charcoal stoves);

(iv) Substitution of wood derived products for renewable sources;

(v) Rural electrification; and

(vi) Modernisation and intensification of agriculture.

8.2 Criteria for identification of mitigation options

Identification of potential mitigation options involves the determination of relevant options, and methods for analyzing the options. This involves data collection and review. This study makes a forest and land use sector analysis in respect of its development and associated greenhouse gases emissions.

The main purpose of forestry mitigation options is terrestrial carbon storage, which would reduce atmospheric accumulation and thus delay its impact on global climate. The greenhouse gas mitigation options in the forestry and land use sector may be classified into three basic types (20). One option is to expand vegetation stocks and the pool of carbon in wood products. Expansion will capture carbon from the atmosphere and maintain it on land over decades. The second option is to maintain the existing stands of trees and the proportion of forest products currently in use. Maintenance of the existing forests, whether achieved through reduced deforestation, forest protection or through improved cook stoves, lengthens the duration the carbon stays trapped in trees and provides immediate carbon benefit. For example, tropical forest vegetation and soils contain 20 - 100 times the amount of carbon in croplands and pasture cleared from forests. Hence maintenance of forests is a much more effective mitigation option, but difficult to implement, since the land is often far more valuable deforested than forested.

In order to decide on which mitigation measure is suitable, land-based products supply is matched with the capacity of the land to meet the demand. Mitigation of GHG emission requires improvement of existing land-use management, enhancement of land-use productivity, and calls for measures to halt deforestation. These options result in more carbon storage in vegetation and soil (1,3). The forestry and land use mitigation options may offer bridging opportunities to buy time for policy makers to develop the technologies and policies capable of altering the major sources of emission to fossil fuel consumption patterns and technologies.

8.3 Comprehensive Mitigation Analysis Process (COMAP)

The Comprehensive Mitigation Analysis Process (COMAP) is a model used to evaluate the forestry mitigation options by analyzing the economic and other parameters of the mitigation options.

The approach consists of the following procedures:- (20)

i. Identification and screening potential mitigation options appropriate for Carbon sequestration

ii. Assessment of the current and future land area available for the selected mitigation options

iii. Assessment of the current and future wood-product demand

iv. Determination of the land area and wood production scenarios by mitigation option

v. Estimation of the carbon sequestration per unit area for major available land classes, by mitigation option

vi. Estimation of the unit costs and benefits

vii. Evaluation of the cost effectiveness indicators for ranking mitigation options and compare with other sectors

viii. Development of future carbon sequestration and cost scenarios

ix. Assess macro-economic effects of scenarios (e.g. capital, GDP, export etc.)

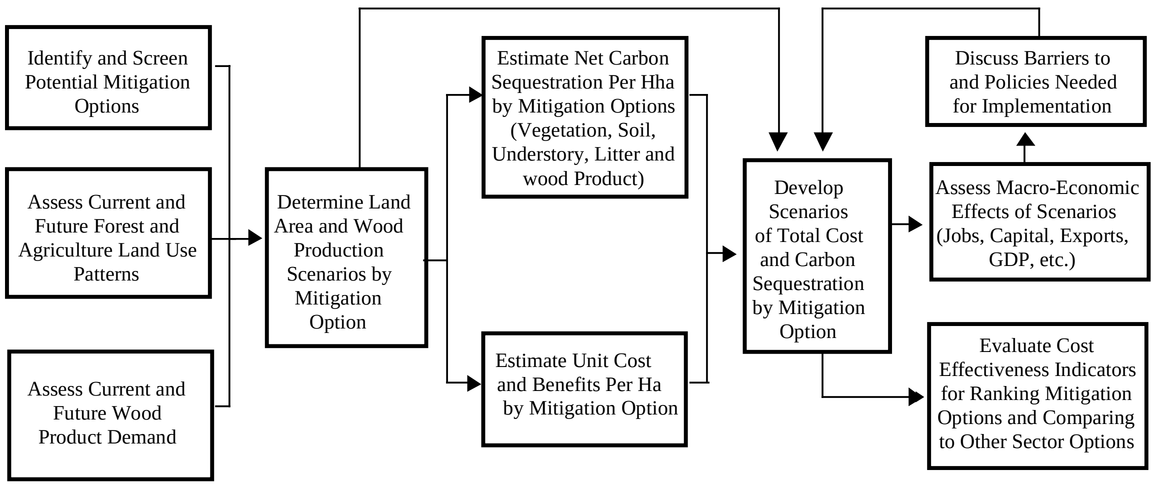
x. Estimation of unit cost and benefits per ha by mitigation option and compare with other sectors

xi. Exploration of the policies, institutional arrangements and incentives necessary for the implementation of options

8.4 Implementation of COMAP

Potential mitigation options have been identified in the "Enhanced TFAP" and the "Mitigation" scenarios. Data for the determination of the land area involved in the mitigation options have been obtained from the programmes proposed in the two scenarios. Therefore a project to project evaluation has been undertaken in the COMAP analysis and the process has been as illustrated in Figure 8.1.

Figure 8.1 Comprehensive Mitigation Analysis Process (COMAP) for Forestry



Source: (13)

The COMAP model developed by the Lawrence Berkeley Laboratory has the following spreadsheets:-

- Opening section with guidance on data input requirements, goals, and expected outputs;
- Data entry spreadsheet for the relevant mitigation option; and
- Results section showing results of the cost benefit analysis as well as GHG reduction/sequestration effects of the mitigation project in question.

Assumptions made regarding the rotation and yield expressed in the Mean Annual Increment (MAI) are shown in Table 8.1.

Table 8.1 Assumptions about the MAI

Species	Rotation (Years)	MAI (m^3ob/ha/annum)
Pine Cypress	25	25
Pine/Pulpwood rotation	15	17
Eucalyptus	10	30
Teak	60	10

8.4.1 Sao Hill reforestation option

The first mitigation option analysed using the model is the estimation of carbon sequestration and storage potential in vegetation, soil, litter, and products for Sao Hill reforestation project. We also estimated cost effectiveness parameters for the project.

Actual work involved in the reforestation of Sao Hill include nursery for raising seedlings, land preparation for the plantation, (including clearing, heaping, burning, stacking, pitting etc.) planting of trees and beating up (i.e. gap replacing after seedlings not survived). All these activities have been included in the fixed costs of the project. Other activities included in the recurrent costs of the project include thinning and pruning, weeding in order to reduce competition for water and nutrients and to avoid suppression and too much shade, and also reduce risk of fire, pests and diseases. It also reduces chances of grazing animals. Weeding is usually carried out twice a year for a few years after planting.

Table 8.2 Sao Hill Forest Plantation and Expected Expansion (Hectares)

	Softwood (ha)	Hardwood (ha)	Total (ha)
Existing forest			
Division I	22,203.0	1,570.5	23,773.5
Division II	1,335.2	1,029.8	2,365.0
Division III	13,895.0	7.8	13,902.8
Total	37,433.2	2,608.1	40,041.3
Planned Extensions			
Phase I (Pine Cypress)	10,000		10,000
Phase II (Pine Pulpwood)	10,000		10,000

Model Inputs for the Sao Hill

1. Land area to be reforested annually has been taken from the Sao Hill expansion plans and the projections made in the TFAP. The TFAP target is to expand the forest from its current 40,000 hectares to 60,000 hectares. We assume that half of the area will be planted Pine Cypress while the other half will be planted with Pine pulpwood. The

rotation for the two species is 25 years and 15 years respectively. The Sao Hill Forest plantation and expected expansions is as shown in Table 8.2. The Mean Annual Increment for the two species in m^3 of biomass/ha/annum is 25 and 17 for Pine Cypress and Pine/pulpwood respectively.

2. Wood productivity is also considered in the model for the rotation periods considered.
3. Carbon sequestered in soil, litter fall, for the rotation periods has been estimated.
4. Costs of raising plantation, both capital and operation and maintenance costs have been applied for the Sao Hill forest on the basis of 1985 Dollar equivalent shillings at constant prices. The costs referred to are as shown in Table 8.3, for Cypress/Sawlog and Table 8.4 for Pine/Pulpwood.
5 Benefits from timber, and non-timber products like fence poles, fuelwood, slabs, and withies, have also been considered in the model.

Table 8.3 Pine Cypress/sawlog rotation costs for 25 years rotation period

	Direct costs		Indirect Costs		Total costs	
	Tshs	US$	Tshs	US$	Tshs	US$
Investment Costs	5,300	304	660	38	5,960	342
Operation and Maintenance Costs	2,500	143	15,840	908	18,340	1051
Monthly Operation and Maintenance cost						42

Source:(30)

Table 8.4 Pine/pulpwood rotation costs for 15 years rotation period

	Direct costs		Indirect Costs		Total costs	
	Tshs	US$	Tshs	US$	Tshs	US$
Investment Costs	4,300	247	530	30	4,830	277
Operation and Maintenance Costs	1,350	77	7,950	456	9,300	533
Monthly Operation and Maintenance costs						35

Source:(30)

All input data from year 1999 to 2030 on annual and rotation period basis for Baseline and Mitigation scenario have been analysed using the COMAP model.

Outputs for Sao Hill Option

The output spreadsheet of the model has provided the estimates of the cost-effectiveness of reforestation of Sao Hill Forest. It should be noted that two species considered in the model were analysed in separate spreadsheets, that is pine cypress (logwood) (phase I) and pine pulpwood (phase II) for timber and pulp production respectively. Evaluation of cost-effectiveness for each species is as shown in Table 8.5.

Costs in terms of dollar per tonne of carbon sequestered ($/tc) are divided into investment cost and life cycle costs. Therefore Dollar Net Present Value per carbon emission reduction or sequestered ($NPV/C) has been obtained for both options.

Table 8.5 Cost-Effectiveness Indicators for Sao Hill Reforestation

Indicator	Unit	Phase I Results	Phase II Results
Net present value of benefits (NPV)	$/tC	9.15	5.07
	$/ha.	685	150
Benefit of reducing atmospheric carbon (BRAC)	$/tC-yr.	0.069	0.038
Initial cost	$/tC	0.7	0.6
	$/ha.	51	17
Endowment (present value of costs)	$/tC	1.30	2.65
	$/ha.	97	78

8.4.2 An option of extension and replanting of other industrial forest plantations

Extension and replanting existing forests will enhance the vegetation stocks and the pool of carbon in wood products, which may involve a set of activities mostly in rural areas including the following:-

- Smallholder or village tree growing and management for multiple purposes, including agroforestry, with woodfuel provision for own-use as one objective. The priority given by local people to growing trees for woodfuels varies greatly according to farming systems and the amount of accessible forest or other tree resources in relation to consumption levels.
- Also tree growing can be for 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;
- Urban and Community Forestry
- Enhanced Regeneration

Forests, which can be expanded and relevant acreage, are as shown in Table 8.6.

Table 8.6 Possible extension of other forests

	Name of the Forest	Main Species	Existing Forest Area (Hectares)	Possible Extension of Planted Area in (Hectares)
1.	Meru	Eucalyptus	3,482.3	821
2.	Training Forest	Eucalyptus		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	60,000
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: (30)

As in the other options the reforestation analysis was carried with the objective of estimating Carbon sequestration and storage potential in vegetation, soil, litter, and products as a result of undertaking reforestation activities. Using the COMAP estimation of cost effectiveness parameters is also made.

For the purpose of this study not all the forests seen in Table 8.6 are considered. Forests included in this option are extension planting for the North Kilimanjaro, Rondo, and Kawetire plantation forests.

Inputs for reforestation option:

1. Land area for reforestation annually for the North Kilimanjaro, Rondo and Kawetire forests.
2. Wood productivity and Carbon sequestration in soil, litter fall, and the relevant rotation period for the species in question have been considered in the three forests.

3. Costs of raising a plantation of each species have been considered and are as shown in Tables 8.7 and 8.8.
4. Benefits from Timber, Fuelwood and Non-timber products.

Table 8.7 Eucalyptus theoretical cost structure (10 years rotation period)

	Direct costs		Indirect Costs		Total costs	
	Tshs	US$	Tshs	US$	Tshs	US$
Investment Costs	4,300	247	660	38	4,960	284
Operation and Maintenance Costs	4,720	271	19,800	1,135	24,520	1,406

Table 8.8 Teak theoretical cost structure (60 years rotation period)

	Direct costs		Indirect Costs		Total costs	
	Tshs	US$	Tshs	US$	Tshs	US$
Investment Costs	3,800	218	660	38	4,460	256
Operation and Maintenance Costs	2,330	134	39,600	2,270	41,930	2,404

All input data from year 1990 to 2030 on annual and rotation period basis for baseline and mitigation scenario.

The cost effectiveness indicators for the Rondo, North Kilimanjaro and Kawetire reforestation options are as shown in Table 8.9.

Table 8.9 The COMAP cost/benefit indicators for the reforestation option

Indicator	Units	Rondo	North Kilimanjaro	Kawetire
Net Present Value of Benefits	$/tC	0.59	9.15	2.88
	$/ha	52	685	575
Benefit of Reducing Atmospheric Carbon (BRAC)	$/tC-yr.	0.004	0.069	0.022
Initial Cost	$/tC	0.2	0.7	0.3
	$/ha.	17	51	51
Endowment (Present Value of Costs)	$/tC	2.35	1.30	0.52
	$/ha.	209	97	104

8.4.3 Natural/catchment forest protection option

Forest protection will maintain the existing stands of trees and the proportion of forest products currently in use. This may involve the following activities:-

- Sustainable use of forest resources through harvesting 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 greater productivity of village forest land. Improved control against unlicensed felling in these lands is important in order to raise village incomes but does not, of course, add to 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 letter may reduce rural supplies 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 cutting rate is critical. If the rate is greater than local capacity to use the wood, or sell it into commercial markets, the surplus will be burned as a "nuisance".
- Forest Protection and Conservation including protection of wildlife areas
- Increase efficiency in Forest Management, and harvesting,

Three Projects were selected for our analysis, which include the Uluguru South forest, Mount Kilimanjaro forest and Rufiji forest. There are more forests in Tanzania, which could be considered for protection. However, for our analysis we considered the three projects whereby, for example Kilimanjaro is more complex for protection due to land scarcity followed by Uluguru and Rufiji. Cost effectiveness indicators are as shown in Table 8.10.

Table 8.10 Cost effectiveness indicators for forest protection options

	Unit	Uluguru South	Mt. Kilimanjaro	Rufiji
Net Present Value of Benefits	$/tC	-9.96	-19.09	0.04
	$/ha.	-1574	-3017	7
Benefit of Reducing Atmospheric Carbon	$/tC-yr.	-0.747	-1.432	0.003
Initial Cost of Forest Protection	$/tC	0.728	1.423	0.032
	$/ha.	115	225	5
Endowment (Present Value of Costs)	$/tC	10.20	19.23	0.44
	$/ha.	1611	3040	69

8.4.4 Energy production from forestry products (bioenergy option)

The third option is to reduce carbon emission by substituting 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 standing stock of forests; (iii) maintain their carbon sinks.

It is 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 sustainably used to produce electricity as fuels into the turbines.

COMAP has been used to make this analysis for the Sao Hill Forest with the main objectives of:-

- Estimating the potential for bioenergy technology based bioelectricity generation using the by products of Sao Hill Saw Mill given the land availability and efficiency of conversion
- Estimating the potential for fossil fuel electricity substitution through generation of bioelectricity
- Determining Carbon emission avoided and sequestered or stored in soil and standing vegetation

Inputs

- Land area that has been dedicated to growing woody biomass at Sao Hill Forest has been used in this analysis, and considered the by products of the Saw Mill for electricity production;
- Annual productivity of woody biomass has been considered;
- efficiency of conversion of wood to electricity has been taken;
- kWh of electricity generation per tonne of wood has been determined;
- Carbon emission/kWh of electricity generated has been determined; and
- Cost of wood production, electricity generation unit and price of electricity has been determined.
- Table 8.11 shows the input data for the bioenergy option.

Table 8.11 Efficiency of conversion of wood to electricity

Fossil power plant efficiency	0.3
Carbon content of displaced fuel (kgC/GJ)	25.8
Wood power plant efficiency	0.2
Heat value of wood (GJ/tonne)	15
Capacity factor	60%
Gasifier Lifetime (Yrs)	10
Price of fossil-fuelled electricity ($/MWh)	70
Present Value of Capacity Cost ($/MW)	514947
Cost of Electricity Generation ($/MWh)	16
Annual Electricity Generation (MWh/yr)	5256

Outputs

- Total woody biomass production involved in this option has been calculated. This is also used to determine the total electricity generation potential.
- Annual and incremental Carbon emission avoided has been determined;
- Cost effectiveness parameters have been analysed including:-
  - Dollar per tonne of Carbon ($/t C) emission avoided including:-
    - investment cost
    - life-cycle cost
  - The Dollar Net Present Value ($ NPV) of benefits per tonne of Carbon sequestered

The cost effectiveness indicators for a bioenergy project are as shown in Table 8.12.

Table 8.12 Cost effectiveness indicators of the bioenergy project

Indicator	Unit	Value
Net Present Value of Benefits	$/tC	8.60
	$/ha.	610
Benefit of Reducing Atmospheric Carbon (BRAC)	$/tC-yr.	0.065
Initial Cost	$/tC	0.6
	$/ha.	41
Endowment (Present Value of Costs)	$/tC	1.29
	$/ha.	92

8.5 Discussion of the results of COMAP

The indicators obtained in the COMAP analysis can be used as a decision-making criterion for selecting greenhouse gases mitigation projects. The carbon sequestration potentials of the projects are shown in the carbon-pool segment of the spreadsheet, which measures the incremental carbon pool created by the project. Table 8.13 shows the results of the carbon pool created by the various forest projects. For comparison purposes the project with largest amount of carbon pool will be selected, pending comparison of the costs and other social aspects.

Table 8.13 Carbon pool and cost effectiveness indicator results

Mitigation Option	Annually Created Incremental C Pool (Gg)	Present Value of Benefits $/tC	Present Value of Costs $/tC	Net Present Value $/tC
Sao Hill Bioenergy Option	2,270	8.60	1.29	7.31
Uluguru South Forest Protection Option	2,467	-9.96	10.20	-20.16
Mt. Kilimanjaro Forest Protection Option	3,304	-19.09	19.23	-38.32
Rufiji Forest Protection Option	3,003	0.04	0.44	-0.4
Sao Hill Reforestation Phase I	1,198	9.15	1.30	7.85
Sao Hill Reforestation Phase II	444	5.07	2.65	2.42
North Kilimanjaro Reforestation	3,194	9.15	1.30	7.85
Rondo Reforestation	1,331	0.59	2.35	-1.76
Kawetire Reforestation	3,194	2.88	0.52	2.36

The results also show the cost aspects of the projects. Where there are any two or more projects one is comparing, questions that should be answered by the decision-maker include: (i) whether either projects should be undertaken at all; (ii) whether they are admissible; and (iii) if the projects are admissible which one is preferable to another. In answering these questions comparison of costs and benefits of the projects is undertaken using a Net Present Value (NPV) indicator, which is a result of a stream of discounted benefits less the discounted costs. Wherever NPV is greater than zero then the project is admissible because the benefits exceed the costs. If both projects are admissible the one with higher NPV will be chosen.

Out of the 9 projects analysed in Table 8.13 almost all except the Sao Hill reforestation phase II have considerably high carbon sequestration potential. The most favourable projects in terms of costs are the Sao Hill phase I, which has the highest NPV, followed by the North Kilimanjaro reforestation project and the Sao Hill bioenergy project.

The Net Present Value (NPV) indicator is a measurement of economic efficiency for any investment decision making. However in evaluating forestry projects economic efficiency is not the only objective. Furthermore, there are other parameters, which makes the NPV not sufficient for investment decision making.

The Present Value of Costs can be used where it is difficult to assign monetary value to the streams of benefits, which makes the NPV of not much use. It can also be used where the sole interest is Carbon sequestration and where no much interest is on the other associated project benefits. Also where the main constraint is the initial investment one will be concerned with the comparison of initial costs of various projects and choose whichever is lower for achieving similar goals.

The Benefit of Reducing Atmospheric Carbon (BRAC) is an indicator, which incorporates costs, benefits and carbon sequestration in one function. Though controversial since it tries to discount carbon, it is a good measure of comparison of projects in terms of cost/benefits (financial) as well as carbon sequestration potentials.

8.6 Wood energy technologies in the residential sector

COMAP is being updated so as to cover mitigation assessment in respect of improved wood energy devices. It is expected to relate forest acreage with the wood energy requirements, and associated emissions/acreage savings resulting from device efficiency improvements. However in this study residential and commercial wood energy use has not been analysed using COMAP. Instead simple computations were made using penetration of efficient wood energy devices and emission factors.

Technological options for improving energy efficiency in residential and commercial sectors include using available devices as aids in changing energy consumption habits and improving the existing technologies. Another option is the development of new technologies which results in substantial, long-term energy saving. Purchase of efficient appliances is the best way to avoid high costs of energy. There are also important management strategies that can reduce operational costs in existing and even in new and efficient appliances by 10 - 20%.

8.6.1 Charcoal Stoves

The traditional charcoal burning metal stove (jiko) is widely used in urban areas. Its efficiency ranges from 12% to 15%. Indians who came to East Africa as traders and labourers in various development projects in the early 1900s (27) introduced this technology in the country. Other traditional woodfuel utilization technologies such as ovens for baking and meat roasting have heat transfer efficiencies of less than 20%. The efficiency of such technologies could be increased to more than 35% by introducing a clay liner and using double metal wall for increased insulative properties and heat retention.

There are four types of improved charcoal stoves:

(a) The mud-ceramic stove comprising of an outer mud frame cladding with ceramic firebox. Its efficiency is about 26%;

(b) The double metal wall stove insulated by air between the two walls. Its efficiency is about 30%;

(c) The metal-ceramic stove consisting of metal frame cladding and inner ceramic firebox. Its efficiency is 30%; and

(d) The improved charcoal stove is a double ceramic wall stove bound together by metal frame with vermiculite insulating layers between the two walls. The stove has three main components:

    (i) An outer metal cladding with a doorframe, pot rests and stove legs;

    (ii) Ceramic cladding with ash pit and air inlet; and

    (iii) Clay liner firebox. Initial laboratory and kitchen tests indicate its efficiency is of the order of 50%.

8.6.2 Charcoal kilns

Traditional charcoaling technology used in Tanzania is the pit kiln. These have proved to be inefficient with considerable amount of losses. The latest efforts to improve charcoaling efficiency have been undertaken by the Ministry of Energy and Minerals in the Energy 1 Project. The project was based on recognition and identification of charcoal production systems and their requirements. These systems include the existing traditional charcoal producers and potential industrial producers.

Efficient charcoal kilns include the Casamance Kiln and the Half-Orange Kiln. The Casamance Kiln was first developed and demonstrated in Casamance region of Senegal. It has the following advantages over the traditional kiln:

- It is very similar and easily adaptable to the traditional production system while it increases yield by 15%.
- The cycle time is about half that of the traditional kiln.
- It has lower capital and maintenance costs as compared to the brick kiln or metal kilns, but higher than the traditional earthbound kiln; and
- Mobility is reasonably good and the technique is adaptable to all types of terrain.

The Half-Orange Kiln has the following advantages over the traditional earthbound ones:-

- It has a higher conversion efficiency of up to 33%;
- It has an operating cycle of 22 hours or less;
- The carbonisation process is controllable; and
- Recovery of charcoal is uncontaminated by dirt.

The above advantages of the charcoal production technologies have an implication in reduction of GHG emissions. This is due to the fact that any saving of material and time has implications on the amount of GHG emitted and of trees cut for that matter.

To ascertain the energy consumption by end uses it is important to know the energy intensities per activity for each and every end use device. Table 8.14 shows the build-up of the energy intensity per activity, the activity measure being the household. Column A gives the estimate of the rate of utilisation of the end use device. Column B gives the average electrical power requirement for the household. Column D and F show the annual energy requirement by the household for each of the listed end use devices.

Table 8.14 Energy intensities of end-use devices per activity

Device Name	Rate of use	Power Rating	Duration	Energy Intensity in Physical Units	GJ per Physical Units	Energy Intensity (GJ)
	A	B	C	D = A x B x C	E	F = D x E
Wood Fire	250 kg/month		12 months	3.0000 MT	16.030	48.089
Jiko	80 kg/month		12 months	0.9600 MT	28.934	27.776
Jiko Bora	40 kg/month		12 months	0.4800 MT	28.934	13.888
Crop Residue Stove	97 Kg/month		12 months	1.1580 MT	16.030	18.562
Other Devices	6 hrs/day	5 W	365 days	0.0110 MWh	3.612	0.04

Jiko is a traditional wood or charcoal stove. *Jiko Bora* is an improved wood or charcoal stove.

8.6.3 Dissemination of improved charcoal stoves

In 1990 only 4.9% of the urban households had improved charcoal stoves (3). The latter have the efficiency of between 30% and 35% compared to 8% to 15% for traditional charcoal stoves (jiko). The costs of jiko and Improved jiko in 1990 were TShs 200 and 541, respectively. (12)

The potential of further reducing charcoal consumption exists if by the years 2000, 2010 and 2020 the ratios of the urban households using improved charcoal stove reaches 10%, 30%, and 90%, respectively. This would be achieved through its extensive dissemination. It is estimated that in the year 1990 there were about 78,743 improved charcoal stoves. The annual penetration rate in the reference scenario is 3% annually reaching a saturation of 90% in the year 2020. With an option of the penetration of 5%, by the year 2010 all urban households will be using improved charcoal stoves having at least 30% efficiency.

8.6.4 Dissemination of improved wood stoves

Fuelwood is the major source of energy in rural areas. The penetration of improved wood stoves by the year 2020 will not be as high as that of the improved charcoal stoves. This is because in most of rural areas the traditional woodstoves are also used to provide lighting and heating. From the current level of dissemination the penetration is assumed to be only 20% by the year 2020.

There are two common types of technologies of improved wood stoves in the country. These are portable metal/ceramic stove and mud/ceramic fixed stove. Their efficiency ranges from 15% to 20%. The traditional wood stoves have the efficiency ranging from 5% to 10%. Introducing improved wood stoves with an efficiency of 20% and assuming an annual penetration rate of 2% means that by the year 2020 there will be 1,816,018 improved wood stoves.

8.6.5 Crop residue stoves

Introducing improved crop residue stoves with 15% efficiency and a penetration rate of 1% per annum means that by the year 2020 there will be 163,222 improved crop residue stoves. Table 8.15 gives projections of biomass use devices in the residential sector.

8.6.6 Dissemination of efficient charcoal kilns

Dissemination of efficient charcoal production kilns will facilitate conservation of forest resources as well as reducing GHG emissions. As already mentioned introduction of Casamance Kiln will increase production efficiency and charcoal yield by 15% while introduction of Half-Orange kiln will increase efficiency up to 33%. While Cassamance Kilns are more suitable for small-scale charcoal producers the Half-Orange charcoal kilns are more suitable for industrial production of charcoal.

Table 8.15 Projections of biomass end-use devices in household sector

Device	1990	2000	2010	2020
Woodfire	2,666,000	2,196,000	1,730,000	1,211,000
Improved Wood Stove		549,000	1,153,000	1,816,000
Crop Residues Stove	640,000	605,000	484,000	381,000
Improved Crop Residue Stove		67,000	121,000	163,000
Traditional Charcoal Stove (*jiko*)	709,000	433,000		
Improved Charcoal Stove (*jiko bora*)	79,000	433,000	973,000	1,048,000

8.6.7 GHG emissions from improved biomass energy end-use devices

In the absence of a COMAP analysis for options of using improved biomass energy a simple computation of emissions using the device efficiency and penetration rates has been adopted. It can be noted that efficient end-use devices will decrease the biomass energy consumption. The projections of energy consumption in the household sector are shown in Table 8.16. The projections of energy consumption in the commercial sector are given in Table 8.17. The emissions under this mitigation option are given in Table 8.18.

Table 8.16 Projection of biomass energy consumption by end use devices in household sector ('000 GJ)

Device	1990	2000	2010	2020
Woodfire	128,000	61,000	48,000	34,000
Improved Wood Stove		11,000	23,000	36,000
Crop Residues Stove	12,000	14,000	13,000	11,000
Improved Crop Residue Stove		1,000	2,000	2,000
Traditional Charcoal Stove	19,000	6,000		
Improved Charcoal Stove	1,000	4,000	10,000	10,000

Table 8.17 Projection of biomass energy consumption by end use devices in commercial sector ('000 GJ)

Device	1990	2000	2010	2020
Woodfire	1000	1,200	1,500	1,600
Improved Wood Stove		200	500	1,600
Traditional Charcoal Stove	300	300		
Improved Charcoal Stove	30	200	500	800

Table 8.18 Emissions resulting from using efficient devices

RESIDENTIAL SECTOR									
Base case									
	2000			2010			2020		
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	805	55		885	61		974	67	
Charcoal Consumption	124	1		137	1		150	1	
Charcoal Production	1,212	83		1,334	91		1,467	100	
Crop Residue	63	4		69			76		
Total	2,204	143		2,425	153		2,667	168	
Mitigation Case									
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	250	17	3	249	17	3	246	17	3
Charcoal Consumption	47		1	45		1	48		1
Charcoal Production	461	32	5	437	30	5	468	32	5
Crop Residue	53	4	1	59	4	1	50	3	1
Total	811	53	10	790	51	10	812	52	10
COMMERCIAL SECTOR									
Base Case									
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	17	1		53	3		165	10	
Charcoal Consumption	6			16			47	1	
Charcoal Production	60	3		171	10		491	28	
Total	83	4		240	13		703	39	
Mitigation Case									
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	16	1		22	1		35	2	
Charcoal Consumption	4			5			8		
Charcoal Production	47	3	1	54	3	1		5	1
Total	67	3	1	81	4	1	43	7	1

8.6.8 GHG emissions from fuel switching and rural electrification options

Fuel switching is an option for reducing energy consumption in (or emissions from) both residential and commercial sectors. One alternative is for urban households to switch from using fuelwood to charcoal or from charcoal to electricity. For the commercial sector, the possibility is for a switch from fuelwood and charcoal to electricity in food preparation.

With an increase in electricity generation and the rural electrification drive, it is possible to have at least 60% of rural households electrified by the year 2020. There is therefore a possibility for fuel switch from kerosene to electricity for lighting end-use. Furthermore, with improving standard of living in urban areas, there are possibilities that 50% of the urban households will be able to own electric cookers, by the year 2020. This will cause switching from biomass energy to electricity for cooking in urban areas. It is also feasible that by the same year no sub-sector of the commercial sector will be using fuelwood for food preparation. The above options are presented in Table 8.19.

Table 8.19 Penetration of electric lights and electric hot plates

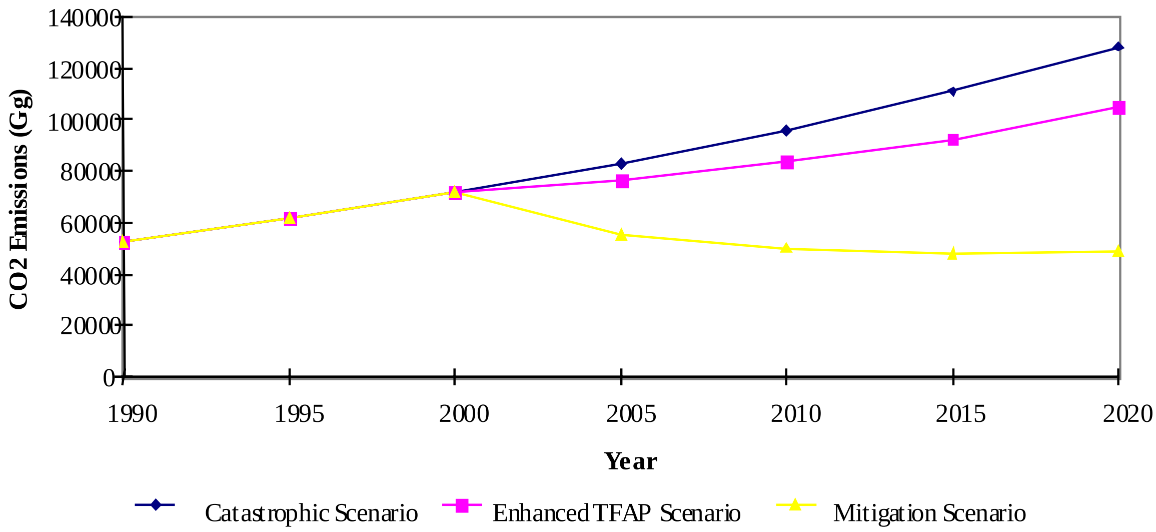
Year	1990	2000	2010	2020
Percentage of Rural Households Switching From Kerosene Lamps to Electric Lights	2.5	10	30	60
Percentage of Urban Households Switching From Charcoal Stoves to Electric Hot Plates	10	20	30	50
Percentage of Switching From Fuelwood to Electric Hot Plates in Commercial Sector	10	20	60	100

Table 8.20 Emissions resulting from switching to electricity

COMMERCIAL SECTOR									
Base Case									
	2000			2010			2020		
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	17	1		53	3		165	10	
Charcoal Consumption	6			16			47	1	
Charcoal Production	60	3		171	10		491	28	
Total	83	4		240	13		703	39	
Switching to Electricity Case									
	2000			2010			2020		
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	12	1		37	2		0		
Charcoal Consumption	4			11			33	1	
Charcoal Production	42	2		120	7		344	20	
Total	58	3		168	9		377	21	
RESIDENTIAL SECTOR									
Base Case									
	2000			2010			2020		
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	805	55		885	61		974	67	
Charcoal Consumption	124	1		137	1		150	1	
Charcoal Production	1,212	83		1,334	91		1,467	100	
Crop Residue	63	4		69			76		
Total	2,204	143		2,425	153		2,667	168	
Switching to Electricity Case									
	2000			2010			2020		
	CO	CH_4	NO_x	CO	CH_4	NO_x	CO	CH_4	NO_x
Fuelwood	564	39	6		43	7	682	47	8
Charcoal Consumption	87		1			1	105		1
Charcoal Production	849	58	9		64	10	1027	70	11
Crop Residue	53	4	1		4	1	76	4	1
Total	1553	101	17		111	19	1890	121	21

In the mitigation scenario, due to sustainable management and use of forest resources it is expected that rate of deterioration of capacity of forests to sequester carbon will gradually diminish. This analysis did not consider the impact of intensification and mechanisation of agriculture, and therefore the status of clearing of forests for agriculture will remain as it is in the enhanced TFAP scenario. Figure 8.2 shows the comparison of the emissions from the three scenarios.

Figure 8.2 Comparison of CO_2 emissions from the three scenarios



9 Conclusions

This study has analysed the forestry and land use sector behaviour on the basis of the current policies on land and environment. Furthermore three scenarios have been developed on the basis of what is expected to happen in the sectors, the worse scenario being a catastrophic one where if things takes the business as usual trend then the forest resources will easily be depleted. The TFAP scenario takes into account the implementation of the current plans as scheduled while the mitigation scenario takes into account the GHG mitigation in the implementation of the plans. A Comprehensive Mitigation Analysis Process (COMAP) has been used to analyse the GHG and cost implications of the various programmes under the mitigation scenario.

The greenhouse gas mitigation analysis in the forestry sector suggests a number of ways in which sustainable management of forestry resources can be achieved. These can be grouped into two categories namely, interventions that would create public good and as such forest protection and conservation falls under this category. Such programmes can be expensive and can also take time to realise the expectations. The other category involves the establishment and management of forest plantations including sustainable harvesting of the forestry products, whether it being timber or inputs for bioenergy production. Such projects are attractive even for private investment.

Ranking of the forestry projects has been possible using economic efficiency indicators and the carbon sequestration potential of the project in the COMAP as in Table 8.13. However, these indicators are not enough to tell, for example, why should a foreign company be interested to invest in a forestry project in Tanzania under a Clean Development Mechanism (CDM) or any other arrangement. This will require further studies on the individual firms' behaviour using econometrics and optimisation approach. The analysis in this study is nevertheless a good input in making selection from a bundle of forestry projects on the basis of their costs and benefits including carbon storage potential and other associated economic benefits.

Linkage of energy and forestry sector has been an important part of this analysis, for forestry resources are important inputs to the energy economy in Tanzania. For this study two types of analysis have been undertaken in relation to energy and forestry linkages, namely the bioenergy project, and the wood energy technology improvements. However, the latter analysis involved technology emissions implications rather than the implication on the carbon pool.

From the aforesaid it is recommended that the results of this study be input in the sector policies and the national action plan on climate change. It should be noted that there still exist some gaps in data and information, which is required for detailed forestry mitigation assessment. Therefore, capacity building in the relevant sectors should be enhanced so that such activities are undertaken. Bridging of data gaps, widening of methodological approaches and bridging of research needs gap should form the basis of future studies.

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