Federal Democratic Republic of Ethiopia

Ministry of Water Resources

National Meteorological Services Agency

ጢስ አባይ (ጢስ እሳት) ፏፏቴ Tis Abay (Tis Issat) or Blue Nile Falls

Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC)

June 2001

Addis Ababa, Ethiopia

Federal Democratic Republic of Ethiopia

Ministry of Water Resources

National Meteorological Services Agency

Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC)

June 2001
Addis Ababa, Ethiopia

Published by the National Meteorological Services Agency under the GEF supported Climate Change Enabling Activities Project of Ethiopia

For further information please contact:
National Meteorological Services Agency
P.O. Box 1090
Addis Ababa, Ethiopia
Tel: 251-1-512299, 251-1-615779
Fax: 251-1-517066
E-mail: nmsa@telecom.net.et

Project Steering Committee (PSC) members and their role

No.	Name	Role in the PSC	Institution
1.	Mr. Tesfaye Haile/ Mr. Demlew Aweke	Chairman	National Meteorological Services Agency (NMSA) - Ministry of Water Resources (MoWR)
2.	Dr. Tetemke Mehari	Member	Addis Ababa University (AAU)
3.	Mr. Tequame T/Mariyam	Member	Environmental Protection Authority (EPA)
4.	Mr. Asress W/Giorgis	Member	Ministry of Mines and Energy (MoME)
5.	Mr. Million Bekele	Member	Ministry of Agriculture (MoA)
6.	Mr. Hailemariyam Hailu	Member	Ministry of Economic Development and Cooperation (MEDaC)
7.	Mr. Abebe Mekuriaw	Member	Ethiopian Science and Technology Commission (ESTC)
8.	Dr. Kidane Georgis	Member	Ethiopian Agricultural Research Organization (EARO)
9.	Mr. Mitiku Abebe	Member	Christian Relief and Development Association (CRDA)
10.	Mr. Abebe Tadege	Secretary	NMSA

Project Management Team members

No.	Name	Role
1.	Mr. Tesfaye Haile/ Ato Demlew Aweke	National Project Coordinator
2.	Mr. Abebe Tadege	Project Manager
3.	Mr. Yohannes G.Eyesus	Technical Coordinator
4.	Mr. Ademe Mekonnen	Project Meteorologist
5.	Mr. Bedada Balcha	Project Economist
6.	Mr. Habtu G.Yohannes	Project Data Organizer
7.	Mr. Assefa Jeza	Project Accountant
8.	Mrs. Almaz Shiferaw	Project Secretary

Compiled and Edited

by

Abebe Tadege** **(MSc)

National Meteorological Services Agency

Contributors:

Mr. Yohannes G.Eyesus (Meteorologist):	National Meteorological Services Agency
Mr. Ademe Mekonnen (Meteorologist) :	”
Mr. Bedada Balcha (Economist):	”
Mr. Asress W/Giorgis (Energy Engineer):	Ministry of Mines and Energy (EREDPC)
Mr. Dereje Kebede (Mechanical Engineer):	”
Mr. Ephrem Hassen (Energy Planner/Economist):	”
Mr. Worku Gosaye (Petroleum Engineer):	Ethiopian Petroleum Enterprise
Mr. Getachew Worku (Transport Economist):	Ethiopian Road Transport Authority
Mr. Berhanu Kibret (Chemical Engineer):	Ethiopian Chemical Society
Mr. Million Bekele (Forester):	Ministry of Agriculture
Dr. Wondwosen Asfaw (Livestock Expert):	Ministry of Agriculture
Dr. Dagnenet Yemenu (Livestock Expert):	Ministry of Agriculture
Mr. Fikru Tessema (Waste Management Expert):	Addis Ababa Health Bureau
Mr. Adnew Adam (Environmental Technologist):	Addis Ababa Water and Sewerage Authority
Dr. Kidane Giorgis (Agronomist):	Ethiopian Agricultural Research Organization
Mr. Bruke Yemane (Rangeland Expert):	Ministry of Agriculture
Mr. Negash Mamo (Forester):	Forestry Research Center
Mr. Deksyos Tarekegne (Hydrologist) :	Ministry of Water Resources
Mr. Mesfin Lulu (Epidemiologist):	National Health and Nutrition Research Institute
Mr. Tarekegne Abose (Epidemiologist):	Ministry of Health
Mr. Fetene Hailu (Biologist):	Ethiopian Wildlife Conservation Organization

FOREWORD

Scientific measurements have shown that atmospheric concentration of greenhouse gases (GHGs) has been increasing rapidly as a result of human activities such as fossil fuel burning and deforestation. It is believed that increased concentrations of greenhouse gases will lead to global climate change. It is also widely accepted that global climate change would have adverse impacts on socio-economic development of all nations.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 by the international community to combat climate change. Ethiopia signed the UNFCCC at the Earth Summit held in Rio de Janeiro and later ratified it on 05 April 1994. Since then Ethiopia has paid great attention to the issues of climate change and various activities have been undertaken including conducting climate change country studies and participating in climate change negotiations.

There are a number of reasons why Ethiopia should be concerned about climate change. Our main natural resources namely water, forest, biodiversity, agricultural land, energy, etc are very much the reflection of the climate we have. Socio-economic activities such as agriculture which is the main stay of Ethiopia's economy, energy and water supply, human health, etc are also very sensitive to climate variations. Recurrent drought is also the main challenge of the country.

Evidences that could be associated with climate change have already started appearing in Ethiopia. In the last 50 years the annual average minimum temperature over the country has been increasing by about 0.2^0C every decade. We have experienced frequent and extensive droughts in recent decades which caused food shortages and famine. The spread of malaria into highland areas which have never experienced before, loss of biodiversity and a decline in wildlife number have also been observed. Studies already made also indicate that the projected changes in current climate and its variability would have serious implications on our natural resources, economy and welfare.

It is known that most of the historical and current emissions of GHGs originate from developed countries. It can also be noted from this report that Ethiopia's GHG emission is very small compared even to most developing countries. However, climate change is a truly global problem and its solution needs the participation of all nations. As a party to the UNFCCC Ethiopia is willing to contribute to the achievement of the ultimate objective of the Convention despite her very low contribution to the global GHG emissions. There are a number of potential mitigation options/ opportunities, which could meet both objectives of socio-economic development and climate protection.

For example, Ethiopia could contribute to GHG mitigation and pursue sustainable development by exploiting her huge hydro, solar, wind, biomass and geothermal energy resources not only for her own consumption but also for neighboring countries as well, with the financial and technical support from developed countries.

Articles 4 and 12 of the UNFCCC call upon all parties of the Convention to prepare national communications that describe inventories of greenhouse gas emissions and to reduce emissions as well as adapt to climate change.

This report represents the initial formal communication of Ethiopia as required under the Convention. We believe that the Report contains the information required by the Climate Change Convention form Non-Annex I Parties as well as a good description of the situation of the country and a framework data that can serve as a basis for future studies on climate change. It also reflects our capacity building need to implement the commitments we have under the Convention. Since this is our Initial National Communication, many of the findings are a result of preliminary analysis and should be considered with cautions. In this regard, it is expected that there will be a room for improvement and perfection in subsequent national communications.

We have high hopes that developing countries like Ethiopia would get the financial and technical support as well as the transfer of appropriate technology for the implementation of the Convention.

The preparation and submission of this Initial National Communication to the Conference of Parties of the UNFCCC demonstrates Ethiopia's willingness and commitment to work with the international community in attaining the ultimate objective of the Convention i.e. achieving stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous antropogenic interference with the climate system.

It is an honour and a great pleasure for us to present, on behalf of the Government of Ethiopia, the Initial National Communication of Ethiopia to the Conference of Parties through the secretariat of the UNFCCC.

June 2001

Shiferaw Jarso
Minister
Ministry of Water Resource

Tewolde Berhan Gebre Egziabher (Dr.)
General Manager
Environmental Protection Authority

ACKNOWLEDGEMENT

The Initial National Communication of Ethiopia to the UNFCCC is the outcome of the Climate Change Enabling Activities Project that has been going on since 1999. The Project has been financially supported by the Global Environmental Facility (GEF) through the UNDP. We believe that the exercise of the preparation of the National Communication under the Enabling Activities Project, besides meeting our commitments under the Convention, has provided us a great experience that can be used to undertake similar work in the future.

The Government of Ethiopia would like to take this opportunity to express its many thanks to the GEF and the UNDP for their financial and technical support in preparing the National Communication.

We would also like to recognize the UNFCCC secretariat particularly staffs of the Non-Annex I Implementation Program, the United Nations Environmental Program (UNEP) and the National Communications Support Program (NCSP) for arranging workshops, providing and distributing technical materials, information and analytical tools.

The handling and understanding of climate change issues require a multi-disciplinary approach. To this end a Project Steering Committee (PSC) composed of ten representatives from stakeholder institutions has been set up to oversee and give guidance for the preparation of the National Communication. Two technical working groups composed of 15 experts in total have been established to carry out the technical aspects of the Project. Project Support Team has been formed to co-ordinate and follow up the day to day operations of the Project within NMSA. This report is the result of a collaborative work among experts from government, non-government, education and research institutions and professional associations.

NMSA would like to thank members of the Project Steering Committee mentioned on page ii and the two technical working group members indicated in Annex I and II including the organizations they represent for their valuable contribution and input for the preparation of this document.

NMSA is highly indebted to the Ministry of Economic Development and Co-operation (MEDaC) and to the Environmental Protection Authority (EPA) for their approval of the Project and facilitative role they played in its implementation.

Finally, NMSA would like to express its deepest gratitude to the Project Support Team and other staff members who directly or indirectly contributed to the preparation of this National Communication without whose efforts this exercise could not have been successful.

Bekuretseion Kassahun
General Manager of NMSA and
National Focal Point for the UNFCCC

Demlew Aweke
D/General Manager of NMSA and
National Project Co-ordinator

TABLE OF CONTENTS

LIST OF ACRONYMS

AAU:	Addis Ababa University
ACMAD :	African Centre for Meteorological Applications and Development
ADLI:	Agriculture Development Lead Industrialization
AGBM:	Ad-Hoc Group on Berlin Mandate
AIJ:	Activities Implemented Jointly
amsl:	Above mean sea level
AWSA:	Addis Ababa Water and Sewerage Authority
CCCM:	Canadian Climate Change Model
CDM:	Clean Development Mechanism
COMAP:	Comprehensive Mitigation Analysis Process (model)
CoP:	Conference of the Parties
CSA:	Central Statistical Authority
CSE:	Conservation Strategy of Ethiopia
DGM:	Deputy general manager
DMC:	Drought Monitoring Center
DSSAT:	Decision Support System for Agro-Technology Transfer
EARO:	Ethiopian Agricultural Research Organization
EEA:	Ethiopian Energy Authority
EEPCO:	Ethiopian Electric Power Corporation
EESRC:	Ethiopian Energy Studies and Research Center
EFAP:	Ethiopian Forestry Action Plan
EFY:	Ethiopian Fiscal Year
EMA:	Ethiopian Mapping Authority
EPA:	Environmental Protection Authority
EPE:	Ethiopian Petroleum Enterprise
EREDPC:	Ethiopian Rural Energy Development and Promotion Center
ESTC:	Ethiopian Science and Technology Commission
EWNHS:	Ethiopian Wildlife and Natural History Society
FAO:	Food and Agricultural Organization
FCCC:	Framework Convention on Climate Change
FRC:	Forestry Research Center
GCM:	General circulation model
GDP:	Gross Domestic Product
GEF:	Global Environmental Facility
GFD3:	Geophysical Fluid Dynamics Laboratory model-R30
GFDL:	Geophysical Fluid Dynamics Laboratory model
Gg:	Giga gram
GHG:	Greenhouse gases
GIS:	Geographic Information System
GISS:	Goddard Institute for Space Science
GWh:	Gigawatthours
GWP:	Global warming potential
ICS:	Interconnected System
IIASA:	International Institute for Applied System Analysis

INC:	Intergovernmental Negotiating Committee
IPCC:	Intergovernmental Panel on Climate Change
ITCZ:	Inter Tropical Convergence Zone
JI:	Joint Implementation
KP:	Kyoto Protocol
KWh:	Kilowatt hour
LEAP:	Long-range Energy Alternative Planning Model
LPG:	Liquid Petroleum Gas
LUCF:	Land Use Change and Forestry
MCT:	Malaria Control Team
MEDaC:	Ministry of Economic Development and Co-operation
MoA:	Ministry of Agriculture
MoE:	Ministry of Education
MoH:	Ministry of Health
MoME:	Ministry of Mines and Energy
MOP:	Meeting of the Parties
MoWR:	Ministry of Water Resources
MT:	Metric tons
NGO:	Non-Governmental Organization
NMSA:	National Meteorological Services Agency
NMVOC:	Non-Methane Volatile Organic Compounds
NPC:	National Project Co-ordinator
NPPE:	National Population policy of Ethiopia
PMT:	Project Management Team
PSC:	Project Steering Committee
SAR:	Second Assessment Report
SBI:	Subsidiary Body for Implementation
SBSTA:	Subsidiary Body for Scientific and Technological Advice
SCS:	Self Contained Systems
SOC:	Soil Organic Carbon
SPUR2:	Simulation of Production & Utilization of Rangelands
TWh:	Terawatthours
UKMO89:	United Kingdom Meteorological Office model-1989
UN:	United Nations
UNCED:	United Nations Conference on Environment and Development
UNDP:	United Nations Development Program
UNEP:	United Nation Environmental Program
UNFCCC:	United Nations Framework Convention on Climate Change
USD:	United States Dollar
WatBal:	Water Balance
WBISP:	Woody Biomass Inventory and Strategic Planning
WBISPP:	Woody Biomass Inventory and Strategic Planning Project
WG:	Working group
WHO:	World Health Organization
WMO:	World Meteorological Organization

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

MEASUREMENT UNITS

Unit Abbreviation	Measurement Unit Name	Measurement Equivalent
Ha	Hectare	1 Hectare = 0.01 Square Kilometer
Km^2	Kilometer Square	1 Square Kilometer = 1,000,000 Square Meter
Tj	Tetra Joule	1 Tetra Joule = 10^{12} Joules
Tc	Tetra Calorie	1 Tetra Calorie = 10^{12} Calories
C	Calorie	1 Calorie = 4.12 Joules
MJ/Kg	Mega Joule per Kilogram	1 Mega Joule per Kilogram = 10^{6} Joules per Kilogram
MJ/Litre	Mega Joule per Litre	1 Mega Joule per Litre = 10^{9} Joules per Cubic Meter
Kg/Lit	Kilogram per Litre	1 Kilogram per Litre = 1,000 Kilogram per Cubic Meter
Gg	Gigagram	1 Gigagram = 10^{9} Grams
Kg ha^{-1}	Kilogram per Hectare	1 Kilogram per Hectare = 1 Kilogram per 10^{4} per Square Meter
T/h	Tone per Hectare	1 Tone per Hectare = 10^{2} Tone per Square Kilometer or 10^{5} Kilogram per Square Kilometer

EXECUTIVE SUMMARY

1. Introduction

The atmosphere plays a key role in the exchange of radiation energy between the earth and the sun. It is known that the greenhouse effect or the heat trapping property of the atmosphere keeps the annual average surface air temperature of the earth at about 15 ^{o}C. Without this natural phenomena the earth's annual average temperature would be - 18 ^{o}C and life as we know it would not exist at such cold situation. This important function of the atmosphere is being threatened by the rapidly increasing concentration of greenhouse gases (GHGs) in the atmosphere as a result of human interference. At the present time about 7 billion tones of carbon are released annually into the atmosphere from the burning of fossil fuels and deforestation.

What is more worrying is the future. According to the Second Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), if steps are not taken to reduce emission of greenhouse gases (i.e. business as usual scenario), the current mean annual air temperature of the earth will increase by 1.5 - 3.5 ^{0}C towards the end of the 21st century. Such drastic change of climate in a short span of time is expected to have adverse impacts on the socio-economic development of nations.

The international community adopted the UNFCCC at UNCED in 1992 held in Rio de Janeiro to combat antropogenic climate change. Ethiopia ratified the UNFCCC in April 1994. The Climate Convention commits all Parties to develop and submit "national communications" which should contain inventories of greenhouse gas emissions and information on steps taken to implement the Convention at the national level. The Initial National Communication of Ethiopia to the UNFCCC is prepared following the guidelines of the UNFCCC for the preparation of Non-Annex I national communications.

2. National Circumstance

Ethiopia is located between approximately 3^{0}-15^{0} N latitude and 33^{0}-48^{0}E longitude. The country covers a land area of about 1.12 million km^2, occupying a significant portion of the Horn of Africa. It shares boundaries to the east and southeast with Djibouti and Somalia, to the north with Eritrea, to the south with Kenya, and to the west with the Sudan.

Ethiopia is one of the ancient settlements and civilisations in the world. Ethiopia's history starts at Axum in the northernmost part of the country. Axum is the country's most ancient city and the capital of the historic Axumite Empire (4th Century B.C.).

The population of Ethiopia in 1994 (the base year for the Convention) was 53.5 million, the third largest in Africa after Nigeria and Egypt. Most of the population lives (about 85%) in rural areas. Life expectancy at birth is estimated at 49.8 and 51.8 years for males and females respectively, the average being 50.7 years. Currently growth rate of the population is about 3% and the size of population is projected to increase to 129.1 million by the year 2030.

The climate of Ethiopia is mainly controlled by the seasonal migration of the Intertropical Convergence Zone (ITCZ) and associated atmospheric circulations as well as by the complex topography of the country. It has a diversified climate ranging from semi-arid desert type in the lowlands to humid and warm (temperate) type in the southwest. Mean annual rainfall distribution has maxima (>2000 mm) over the Southwestern highlands and minima (<300 mm) over the Southeastern & Northeastern lowlands. Mean annual temperature ranges from < 15 ^{o}C over the highlands to > 25 ^{o} C in the lowlands. In terms of rainfall occurrence one can generally identify three seasons in Ethiopia namely; Bega: - dry season (October- January), Belg: - short rainy season (February- May) and Kiremt: - long rainy season (June- September).

Ethiopia is one of the least developed countries in the world. The Gross Domestic Product (GDP) in 1994 was USD 6108.60 million at factor cost (in constant 1980 dollars) and per capita income of just under USD120.00. The economy of the country is dominated by agriculture with about 50% share while industry and services contributed 11% and 39% respectively to the national GDP in 1994. The main export items of the country are Coffee, hides, oilseeds, beeswax, sugarcane, etc. Real GDP grew by 5.4% in 1994/95. The growth rate of GDP (at current market price) on average was 6.0%, 9.1% and 11.1% during the period of 1980/81-1990/91, 1980/81-1997/98 and 1992/93-1997/98 respectively (MEDaC, 1999). This shows that the economic reform made after the political change in 1991 has brought some improvement in the Ethiopian Economy. The high dependence of the economy on agriculture means that it is very sensitive to climate variability and this could be an important factor to the vulnerability of Ethiopia to climate change. Key socio- economic indicators of the country for 1994 are given in Table ES.1.

The heterogeneity of the land resource endowments has resulted in a number of diverse ecological conditions ranging from semi-desert to alti-montane and different types of land use patterns. The major land use forms are grazing and browsing, cultivation and forests and woodlands. More than 50% of Ethiopia's land is utilised for grazing and browsing. It has to be noted here that grazing and browsing occurs in cultivated areas, in woodlands and forests, bushlands, shrub lands, grasslands, etc. Cultivation forms the second largest (nearly 23%) land use while forests and woodlands cover about 7% of the country. Over 16% are bare land, in the form of exposed rock, salt flats and sand.

Agriculture which includes crops, livestock, forestry, fisheries and apiculture is the most important sector of the national economy and the main source of livelihood for 85 percent of the population. It is the source of 90% of the export earnings and 40-50% of the national GDP. Food crops, industrial crops, export crops (e.g. coffee), livestock and livestock products are the main components of the Ethiopian agriculture. Subsistence mixed farming (cultivation and livestock rearing) and nomadic pastoralism are widely practiced in the highlands and lowlands respectively.

In 1994 cropped land for cereals, pulses and oilseeds was estimated to cover about 6.9 million hectares. The five main cereals (Teff, Maize, Barley, Wheat and Sorghum) cover a very large proportion of the total cultivated land.

The livestock population in Ethiopia that reaches more than 80 million heads is the largest in Africa and the 10th in the world. It constitutes a large component of the Ethiopian agricultural sector and is well integrated with the farming systems found in the highlands and provides the sole means of subsistence for the nomadic pastoralists in the lowlands.

Natural forests in Ethiopia are believed to have once covered 40% of the country's land area. Estimates of the 1994 Ethiopian Forestry Action Plan indicate that the closed natural forests have been reduced to 2.7% of the country and these are found mainly in the southwestern highlands. The annual loss of natural forest cover is estimated to be in the range of 150,000 to 200,000 hectares.

Table ES.1: Major Socio-Economic Indicators for Ethiopia in 1994

Criteria	1994
Population	53,477,265
Relevant areas (in Sq.Km)	1,120,000
GDP (in million US$)	6,108.60
GDP per capita (in US$)	114.22
Estimated share of the informal sector in the economy in GDP (%)	N.A
Share of industry in GDP (%)	11.2
Share of services in GDP (%)	39.1
Share of agriculture in GDP (%)	49.7
Land used for agricultural purposes (cultivation) (in ha)	6,960,180
Urban population as percentage of total population	13.7
Livestock population i.e Cattle + Sheep + Goats+ Horse + Asses + Camels + Mules (no. of heads)	88,319,000
• Cattle	31,450,000
• Sheep	27,527,000
• Goats	19,762,000
• Horse	2,750,000
• Asses	5,200,000
• Camels	1,000,000
• Mules	630,000
• Poultry	54, 000,000
Forest area including high forests, woodlands and bushlands (in ha)	27,900,000
Population in absolute poverty (%)	45.5
Life expectance at birth (years)	50.7
Literacy	23%
• Urban	69%
• Rural	15%

N.A: Not available

Ethiopia has the largest bee population among African countries by having about 10 million bee colonies. The annual honey and beeswax production has been estimated at 3,300 and 3,500 tons respectively and this makes Ethiopia one of the eight countries with the highest production in the world.

Ethiopia is rich in biodivrsity with high endemism. The richness in flora and fauna is a reflection of the diverse ecological setting, climate and topography found in the country. The Ethiopian flora is estimated to contain 6500 to 7000 species of higher plants, of which about 12 percent are endemic. The country has the fifth largest flora in tropical Africa and is one of the 12 Vavilov centres due to its crop genetic diversity. 277 terrestrial mammals and 862 species of birds have been recorded in Ethiopia. Currently there are 9 national parks, 3 sanctuaries, 8 reserves and 18 controlled hunting areas covering a total area of about 192, 000 Km^2.

Ethiopia is endowed with vast energy resources particularly hydropower. Energy supply in Ethiopia is composed of three main sub-sectors, namely; biomass, petroleum and electricity. Currently the energy need of the country is satisfied by wood fuel (77%), dung (7.7%), crop residue (8.7%), Bagasse (0.06%), charcoal (1.15%), electricity (1%), liquid petroleum gas (LPG) (0.05%), and oil products (4.8%). Most of the energy is utilized for household purposes. To date the country's total installed capacity of electricity is about 450 MW.

The conventional transport system in Ethiopia is comprised of a road network consisting of 23,812 kms of classified roads, a single gauge railway line running for a distance of 781 kms from Addis Ababa to Djibouti, two international airports and thirty domestic airports. There are also eleven ships and vessels operating along the routes to western Europe, the middle and far east with gross and net registered tonnage of over 60,000 and 30,000 respectively. Transport services are generally not accessible to the large majority of the rural population and hence there is heavy dependence on walking, head loading and traditional means of transport using pack animals. According to the 1997 vehicle inspection and registration data there were 102,880 operational vehicles in the country.

Ethiopia is the "water tower" of Northeast Africa. There are 12 drainage basins in the country. Most of the rivers in these basins cross the national boundary. The total available water (mean annual flow) is estimated at 111 billion cubic meters and the ground water potential is about 2.6 billion cubic meters while the potentially irrigable land in the country has been estimated at 3.7 million hectares.

Although Ethiopia's water resource is enormous, very little of it has been developed for agriculture, hydropower, industry, water supply and other purposes. To date only about 160,000 ha (about 4%) of the potential irrigable land has been developed. National coverage of potable water supply stood at 26% by 1992 while coverage of sanitation services is only 7% which is low by even the Sub-Sahran standards. There is also a wide divergence in the water supply coverage between urban (76%) and rural (18.8%) areas.

Major environmental problems in Ethiopia include, soil erosion, deforestation, drought, over-grazing, desertification, loss of biodiversity including wildlife and pollution of water.

Ethiopia is a Federal Democratic Republic. Member states of the Federation are the State of Tigray, the State of Afar, the State of Amhara, the State of Oromia, the State of Somalia, the State of Benshangul/Gumuz, the State of the Southern Nations, Nationalities and Peoples, the State of the Gambela Peoples and the State of the Harari People. Addis Ababa and Dire-Dawa are chartered cities. The Federal Government administration is based on parliamentary system. Members of the two parliaments, the House of Representatives and House of Federation, are elected bodies from the people across all the regions and nationalities.

3. National Greenhouse Gas Inventory

The Revised 1996 IPCC Guidelines was used to estimate Greenhouse Gas emissions by sources and removals by sinks in the country for the years 1990-1995. Emissions/removals of six gases namely Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Nitrogen Oxides (NO_X), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOC) and Sulphur Dioxide (SO_2) were addressed from five sectors. As per the guidelines of the Conference of the Parties (CoP), the base year for Non-Annex I party reporting is 1994. Results of the 1994 National GHG Inventory are presented in Tables ES.2 and ES.3 following the IPCC long and short summary formats.

Emissions of Main Greenhouse Gases- 1994

Carbon dioxide (CO_2)

Ethiopia's total (gross) CO_2 emission, excluding the Land-Use Change & Forestry (LUCF) sector, has been estimated at 2,596 Gg in 1994 (Tables ES.2 & ES.3). About 88% of this total CO_2 emission came from fossil fuel combustion in the Energy sector and the Transport (road) sub-sector is the main emitter of CO_2 within this sector. The Industrial Processes sector contributed 12% of the total CO_2 emissions mainly as a result of cement production. In the same year biomass burned for energy, mainly in domestic households, emitted around 66,757 Gg of CO_2. This amount is not added to the total CO_2 emissions as per the IPCC recommendation.

The Land-Use Change & Forestry (LUCF) sector has been a net sink in 1994 which amounted to about -15,063 Gg of CO_2. This amount is a balance between Changes in Forest and Other Woody Biomass Stocks and Forest and Grassland Conversion sub-sectors. The country's stock of natural forests, woodlands, shrubs and plantations sequestered about -27,573 Gg of CO_2 in 1994 while emission of CO_2 as a result of deforestation was estimated to be 12,510 Gg in the same year.

Methane (CH_4)

The national methane emissions totaled about 1,808 Gg in 1994. The Agriculture sector (enteric fermentation) is by far the largest source of methane emissions in Ethiopia followed by the Energy sector resulting from fossil fuel use in the residential sub-sector

(Table ES.2 & ES.3). The Waste and the Land-Use Change & Forestry sectors make a small contribution to the total CH_4 emissions.

Nitrous oxide (N_2O)

The national total Nitrous Oxide emissions have been estimated to be about 24 Gg in 1994. The Agriculture sector is the principal source of Nitrous Oxide emissions in Ethiopia contributing 81% of the total emission mainly as a result of fertiliser use in agricultural soils. The Energy and Waste sectors contribute 12% and 6% respectively to the total national Nitrous Oxide emissions. The contribution of the Land-Use change & Forestry sector to the N_2O emissions is found to be negligible (Tables ES.2 & ES.3).

Aggregated Emissions and Trends

Aggregation of the 1994 CO_2, CH_4 and N_2O emissions across the five sectors using the 1995 IPCC Global Warming Potential (GWP) factors over a 100 years time horizon results a total of about 48,003 Gg CO_2-equivalents excluding CO_2 emissions/removals from the LUCF sector. With the population of 53.5 million for the same year, the per capita emission would be 0.8976 tonnes of CO_2-equivalents per year. Sectorwise Ethiopia' s emission profile is dominated by emissions from Agriculture contributing 80% of the total while gaswise it is dominated by CH_4 contributing 80% of the total CO_2- equivalent emissions in 1994.

There is a general increasing trend of GHG emissions in Ethiopia in the period 1990-1995. The relative comparison of GHG emissions for the years 1990 and 1995 shows that total (gross) CO_2 emissions (i.e. emissions from the Energy and Industrial Process sectors) have increased by about 24% while emissions of CH_4 and NO_X increased by 1% and 119% respectively. Aggregate emissions of GHGs in terms of CO_2 –equivalents has increased by 12%. The sink capacity of Ethiopia in the LUCF sector is also decreasing rapidly. It is important to note that the rate of growth in GHG emissions vary across sectors and sub-sectors.

Uncertainty Assessment

The quality of the activity data and emission factors used in the national inventory of greenhouse gases determines the reliability of the estimates. In this regard high confidence can be put in the estimates of CO_2 emissions from the Energy and Industrial Process sectors. Estimates of CO_2 emissions/removals from the LUCF sector is highly uncertain. A medium confidence can be put on emissions of CH_4 from Agriculture, Waste and Energy sectors. Estimates of N_2O including NO_X, CO, NMVOC and SO_2 could be highly uncertain. In order to reduce the uncertainties in the GHG inventory there is a need to improve the collection and quality of the national data and to develop local emission factors.

Table ES.2: Long Summary Report for National Greenhouse Gas Inventories (Gg) –1994

IPCC TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES 1994 (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals	**2,596**	**-15,063**	**1,808**	**24**	**165**	**7,619**	**396**	**13**
1 Energy	**2,287**	**0**	**1,94.0**	**2.8**	**83.8**	**3,368**	**394**	**13**
A Fuel Combustion (Sectoral Approach)	2,287		1,94.0	2.8	83.8	3,368	394	12.1
1 Energy Industries	182		1.0	0.1	3.4	33.6	1.7	1.9
2 Manufacturing Industries and Construction	496		0.7	0.1	4.4	61.4	1.2	5.6
3 Transport	1,001		0.1	0.0	10.1	49.5	4.9	4.3
4 Commercial/Institutional	143		6.8	0.1	2.5	1,13.2	13.1	0.0
5 Residential	391		1,84.9	2.5	62.4	3,109	3,67.5	0.0
6 Agriculture/Forestry/Fishing	69		0.0	0.0	1.1	0.9	0.2	0.1
B Fugitive Emissions from Fuels	0		0.0		0.04	0.06	0.44	0.7
1 Solid Fuels			0.0					
2 Oil and Natural Gas			0.0		0.04	0.06	0.44	0.7
2 Industrial Processes	**310**	**0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.3**	**0.2**
A Mineral Products	310					0.0	0.2	0.2
B Chemical Industry	0		0.0	0.0	0.0	0.0	0.0	0.0
C Metal Production	0		0.0	0.0	0.0	0.0	0.0	0.0
D Other Production	0				0.0	0.0	2.1	0.0
3 Solvent and Other Product Use				**0.0**			**0.0**	
4 Agriculture			**15,40.0**	**19.7**	**73.8**	**4,003.5**		
A Enteric Fermentation			1,337.0					
B Manure Management			49.5	0.0				
C Rice Cultivation			0.0					
D Agricultural Soils				17.7				
E Prescribed Burning of Savannas			1,48.4	1.8	66.4	3,894.6		
F Field Burning of Agricultural Residues			5.2	0.2	7.4	108.8		
5 Land-Use Change & Forestry		**-15,063**	**28.3**	**0.2**	**7.0**	**247.4**		
A Changes in Forest and Other Woody Biomass Stocks		-27,573						
B Forest and Grassland Conversion	12,510		28.3	0.2	7.0	247.4		
C Abandonment of Managed Lands								
D CO_2 Emissions and Removals from Soil	0							
6 Waste			**45.9**	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**
A Solid Waste Disposal on Land			28.2					
B Wastewater Handling			17.7	1.5				
C Waste Incineration								
Memo Items								
International Bunkers	**NE**							
Aviation	NE							
Marine	33							
CO_2 Emissions from Biomass	**66,757**							

Table ES.3: Short Summary Report for National Greenhouse Gas Inventories (Gg) -1994

IPCC TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES 1994 (Gg)										
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals		**2,595**	**-15,063**	**1,808**	**24**	**165**	**7,619**	**396**	**13**
1 Energy	Reference Approach	**2,919**							
	Sectoral Approach	**2,285**		**194**	**3.0**	**84**	**3,368**	**394**	**13**
A Fuel Combustion		2,285		194	3.0	84.0	3,368	394.0	12.1
B Fugitive Emissions from Fuels		0		0		0.04	0.06	0.44	0.7
2 Industrial Processes		**310**		**0**	**0.0**	**0.0**	**0**	**2.3**	**0.2**
3 Solvent and Other Product Use		**0**			**0.0**			**0.0**	
4 Agriculture				**1,540**	**19.7**	**73.8**	**4,003**		
5 Land-Use Change & Forestry		**0**	**-15,063**	**28**	**0.2**	**7.0**	**247**		
6 Waste				**46**	**1.5**				
Memo Items:									
International Bunkers		**NE**							
Aviation		NE							
Marine		33							
CO_2 Emissions from Biomass		**66,757**							

4. Greenhouse Gas (GHG) Mitigation Options

Attaining the ultimate objective of the UNFCCC requires the participation of all Parties in reducing GHG emissions and enhancing sinks. It has been noted that there is a general increasing trend of GHG emissions in Ethiopia in the period of 1990-1995 and it is expected to increase in the future along with socio-economic development and population growth. On the other hand, the sink capacity of the country in the LUCF sector is decreasing rapidly due to deforestation mainly for agricultural and energy use.

It is obvious that the contribution of Ethiopia to the global emission of GHGs is negligible. While the alleviation of poverty and socio-economic development is Ethiopia's priority, the country is also concerned with the protection of local and global environment. As indicated in the 1994 Environmental Policy, Ethiopia is committed to work with the international community to combat antropogenic climate change.

A number of options which could have the twin objectives of sustainable economic development and GHG mitigation are identified in the Energy, Land Use Change and Forestry, Agriculture and Waste sectors. Some of these options include:

- Promoting the use of renewable energy. Ethiopia could contribute to GHG mitigation by developing and exploiting her huge hydro, solar, wind, biomass and, geothermal energy resources not only for her own consumption but for neighboring countries as well.
- Improving/promoting energy efficiency and conservation e.g. wide dissemination of improved biomass and charcoal stoves, such as 'Mirt Mitad and lackech'.
- Promoting the use of fuels with low carbon content (fuel switching) e.g. exploiting the Ogaden natural gas reserve and use of gasohol (blending of gasoline with ethanol which is a by-product of sugar factories in the country) for various purposes including transport.
- The promotion of the use of smaller cars through tax differentiation based on engine size, expansion of public transport infrastructure, improving the efficiency of operating vehicles by carrying out maintenance, inspections and training, improving urban traffic, promoting environmentally friendly transport modes such as bicycles.
- Improving forest management practices, protection/preservation of existing forests from loses by deforestation and other practices, initiating new afforestation and reforestation programs, rehabilitation of degraded forests, promoting agro-forestry, developing and restoring gallery forests along river banks.
- Increasing livestock productivity through improved nutrition with supplementation and treatment of forages to improve digestibility and through improved genetic characteristics, promoting sustainable agriculture, promoting mixed crop livestock farming practices where appropriate**,** promoting the use of manure-management system facilities, adopting appropriate fertiliser application, promoting conservation tillage techniques to sequester carbon in cultivated soils, rehabilitation of overgrazed watering points and long-term settlement areas and redistribution of manure that is accumulated near these settlements.
- Integrated waste management, composting solid waste of Addis Ababa city and landfill gas recovery from solid waste site of Addis Ababa city.

Implementation of these options with the financial and technical support and appropriate technology transfer from developed countries will enable to reduce GHG emissions and enhance sinks. It should be noted that mitigation options identified in each sector are results of preliminary analysis and further study is highly recommended.

5. Vulnerability Assessment and Adaptation Options

Climate Change is expected to have adverse impacts on socio- economic development of all nations. But the degree of the impact will vary across nations. The IPCC findings indicate that developing countries will be more vulnerable to climate change. Preparing for adaptation to the impacts of climate change by carrying out climate change impact assessments is one of the commitments of Parties under Article 4.1 of the UNFCCC.

The 1961-90 climate has been taken as the baseline climate of the country. Future changes in climate were projected using one-transient and three equilibrium General Circulation Models (GCMs) and incremental scenarios. Socio-economic scenarios have also been prepared until the year 2030.

Five socio- economic sectors namely Agriculture (crops + livestock), Forestry, Water Resources, Wildlife and Human Health have been considered in our vulnerability and adaptation assessment. Models such as DSSAT, WatBal, Holdridge Lifezone and expert judgement were used in the analysis.

A number of climate change impacts and possible adaptation options are identified in each sector. It has been observed that rainfall projections from GCMs which have large uncertainty at the moment very much influences the sign of the impact in some sectors. Details of the vulnerability and adaptation assessment is found in the relevant chapter of this report. It should be noted here that results of the vulnerability and adaptation assessments are preliminary and as such they should not be viewed as technically rigorous and exhaustive. Further work is needed in this area to improve the assessments and reduce uncertainty**.**

6. Policies, Programs and Measures related to Climate Change

Ethiopia has ratified the United Nations Framework Convention on Climate Change (UNFCCC), the Biodiversity Convention, Desertification Convention, Convention and Protocols to protect the Ozone Layer, etc. Accordingly relevant governmental institutions have been entrusted to discharge responsibilities in the area of environment and development and amongst which, the NMSA is mandated to deal with climate related affairs.

Ethiopia has not yet developed specific climate change policies, programs and measures. However there are a number of environmentally oriented policies, strategies and action plans already in place that can directly or indirectly contribute to the objectives of the Climate Convention. These policies, strategies and action plans include the 1994 Environmental Policy, Conservation Strategy of Ethiopia, Population Policy, Science and Technology Policy, Energy Policy of Ethiopia, Agricultural Policy, Water Policy, Forestry Action Plan, Disaster Prevention and Preparedness and Early Warning Policy, Health Policy, Development Plan of the Addis Ababa City Council, etc. Support for the implementation of these relevant policies, strategies and action plans in the form of funding, technical assistance, training and technology transfer through the Convention mechanisms is extremely essential.

7. Research and Systematic Observation

Climate, atmospheric & hydrological monitoring and databases

Climate research and monitoring are also commitments Parties have under the Climate Convention. The responsibility to monitor climate in Ethiopia lies on the National Meteorological Services Agency (NMSA). Currently a network of about 629 (125 principal + 185 ordinary +319 raingauge) meteorological/ climatological stations are run by NMSA nationwide. NMSA also maintains an upper air sounding station and primary data receiver systems for METEOSAT and NOAA satellites at Addis Ababa. Currently there are no greenhouse gas and ozone monitoring stations in the country.

NMSA provides routine information on current climate conditions in the country including monthly and seasonal climate outlooks. Ethiopia actively participates in the World Weather Watch (WWW) program of the WMO by providing daily weather observations from 18 synoptic stations which are disseminated worldwide for use in climate and weather prediction. Ethiopia also cooperates with regional organisations such as the African Centre for Meteorological Applications and Development (ACMAD) and the Nairobi based Drought Monitoring Centre (DMC) in the field of climate and meteorology.

Hydrological monitoring in Ethiopia is carried out by the Hydrology Department of the Ministry of Water Resources. Currently there are about 338 operational stream gauging stations distributed over the major river basins.

Database on energy use and energy balance is maintained by the Ethiopian Rural Energy Promotion Centre (EREPC) of the Ministry of Mines and Energy. An inventory of the woody biomass resources of Ethiopia has been undertaken by the Ministry of Agriculture since 1990 under the Woody Biomass Inventory and Strategic Planning Project (WBISPP). It is expected that the outcome of the Project will provide up-to-date and reliable information on the forest resources of the country. The Central Statistical Authority (CSA) is also one of the main government organ in collecting data and developing databases in Ethiopia.

It should be noted that the existing climatological and hydrological observation network in the country is far from being adequate. The management of the climatological, hydrological and other databases relevant to climate change also needs strengthening and the government of Ethiopia is making efforts towards this end.

Climate research

One of the mandate entrusted to NMSA is to carry out research and studies in the field of Meteorology and the Agency implements this task through its Meteorological Research and Studies Department. So far significant progress has been made in understanding the weather and climate of the country.

With the exception of limited activities at the Department of Geography of the Addis Ababa University, Ethiopian Agricultural Research Organization and the Arbaminch Water Technology Institute, graduate and undergraduate courses/programs including research in Meteorology and Climatology are virtually absent in higher education and research institutions of the country.

Since the issues of climate change are relatively new, research work so far done in the field is also limited in the country. However, the following steps have been taken.

- A Team has been established under the Research and Studies Department of NMSA to co-ordinate and carry out research on climate change issues in the country since 1994.
- A Climate Change Country Study project was undertaken from 1993-1996 with a financial and technical support from the US Government.
- Ethiopia has been participating in the GEF supported Climate Change Enabling Activities Program since 1999.

8. Education, Training and Public Awareness

The importance of Education, Training and Public Awareness in dealing with the challenges of climate change are well recognised by the Convention as stated in its Article 4 and Article 6. Ethiopians need to be made well aware about the commitments of the country under the Convention, the impacts of climate change, adaptation and mitigation options as well as about measures that can be taken at the individual level to combat climate change. In line with this NMSA as a focal institution has made various efforts during the last few years in order to increase general awareness and technical skills in climate change**.** These efforts include producing climate change articles on newspapers and magazines, giving talks in environmental clubs, organising technical and non-technical workshops and seminars on climate change, participating national experts in training workshops, seminars organised abroad including IPCC plenaries and sessions, giving interviews and press releases on climate change on television and radio, etc.
.
The Ministry of Education (MoE) has also made efforts to introduce Environmental Education in the school curricula at various levels. Topics on climate change have been infused with subjects like Geography, Agriculture and Biology. The teaching of Environmental Economics at the Department of Economics in the Addis Ababa University is also worth mentioning.

Despite the above mentioned efforts the level of awareness about the environment in general and climate change in particular is still very low among most Ethiopians. Graduate and undergraduate courses/programs including research in climate change are not yet included in the education system of relevant higher education and research institutions of the country. Climate change is a new and complex issue. Decision makers, professionals and the public at large should be made aware about climate change. Training is also a necessity to implement climate change programs and polices. The effort to raise awareness and to create educated and skilled experts to handle climate change issues should continue through various means such as:

- Producing articles and conducting interviews through the mass media;
- Developing climate change web-site and networking;
- Organising a series of targeted workshops/seminars/ panel discussions;
- Preparing and widely disseminating information and teaching materials as well as fact sheets on climate change including the Initial National Communication of Ethiopia to the UNFCCC;
- Launching climate change courses in universities, teacher training institutions and secondary schools; and
- Short and long term training of national experts in the various aspects of climate change.

9. Financial, Technological and Capacity Building Needs and Constraints

The Convention very well recognises the need for the provision of financial and technical support including technology transfer and capacity building for developing country Parties to fully participate in the implementation of the Convention. As a least developed country Party and as a country which falls under most conditions stated in article 4.8 and 4.9 of the UNFCCC, Ethiopia needs a special consideration for financial and technical support, technology transfer and capacity building in meeting her commitments under the Convention.

Data collection and monitoring

Data generating, gathering, archiving and analysing capability of the country, which is week at the moment, needs to be enhanced. Climatological, hydrological, ecological, biodivesty/wildlife and landuse/landcover monitoring are all essential in dealing with climate change. Relevant institutions such as Ministry of Agriculture, Central Statistical Authority, Ministry of Mines and Energy, Ministry of Water resources need to be strengthened in this respect in terms of manpower, training, and facilities.

Of particular importance is strengthening of the national meteorological and hydrological services of the country by

- Improving the density of the climate and hydrological station network through the establishment of new observation stations and rehabilitating existing ones;
- Improving the communication system for data collection and dissemination;
- Modernizing data base systems including quality control; and
- Short and long term training of staff to maintain the service.

Capacity building in data collection and monitoring will improve the country's ability to produce timely and well processed data to meet the requirement of different users including the supply of data for climate change studies. The country will also have the capacity to be better prepared for extreme events such as drought and to effectively and properly apply climate and hydrological information in decision making and socio-economic development planning.

Training

Skilled human resource development to handle climate change issues is a priority for Ethiopia. There is a need to develop and implement a training program which contains both short-term and long-term training in areas such as vulnerability and adaptation assessment, integrated Assessment, climate variability, climate change detection and climate modelling, mitigation analysis, adaptation and mitigation costing, GHG inventory, mitigation and adaptation technology assessment, transfer and adoption, policy Analysis, program and project development in climate change, formulation and implementation of adaptation and mitigation action plans, Land use planing, use of satellite remote sensing data, Geographic Information System and statistical analysis techniques, etc.

Research and studies

The socio-economic development of Ethiopia is very much influenced by climate and its variability including drought. The IPCC has concluded that climate change will have significant adverse impacts on developing countries like Ethiopia. Therefore there is a need to carry out climate change research and studies to better understand impacts and identify best adaptation options by enhancing national research capacity in the following areas:

- Climate change vulnerability & adaptation assessment in key socio-economic sectors;
- Current climate variability particularly extreme climate events such as drought and flood and its coping mechanisms;
- Integrated assessment;
- Climate change detection and climate modelling;
- GHG inventory and mitigation analysis;
- Adaptation and mitigation costing;
- Technology assessment, transfer and adoption; and
- Policy analysis.

Awareness creation

Awareness about climate change is crucial for the implementation of the UNFCCC. As climate change is a new issue the level of awareness among policy makers, professionals and the general public about it is very low in the country. Therefore, financial support and capacity building to develop and implement climate change awareness program/project is necessary.

Development of national climate change network

Institutional linkages and communication have to be strengthened by building a network of stakeholders through electronic means such as the Internet. This will facilitate exchange of information and experience among experts, national, regional and international institutions. Consultation for project/program preparation and implementation will also be enhanced if there is fast communication means.

Strengthening of the national focal institution

The National Meteorological Services Agency is the focal institution for coordinating climate change issues in the country. The Climate Change and Air Pollution Studies Team of NMSA in particular is responsible for the follow up of the day to day and research activities in climate change. The Team needs to be strengthened in terms of manpower, training and facilities to better co-ordinate climate change issues in the country.

Financial support and capacity building to develop a documentation and information centre under NMSA, to enhance the availability of relevant climate change materials for various audiences will be essential.

The participation of the country in the climate change negotiation process is very weak due to lack of financial support and inadequate negotiation and language skills. Delegation of Ethiopia needs to get training in negotiation skills in the various aspects of the Convention including recent issues such us the Clean Development Mechanism (CDM) as well as in the preparation of key position papers in order to enable them participate effectively and meaningfully in climate change negotiations.

Since climate change is a complex and multi-disciplinary issue it is essential if relevant lead ministries also participate in the climate change negotiations. In this regard adequate financial support is needed to send large enough delegation to cover the important aspects of the Convention meetings.

Mitigation activities and technology transfer

As a party to the UNFCC Ethiopia is willing to contribute to the achievement of the ultimate objective of the Convention despite her very low contribution to the global GHG emissions. There are a number of potential mitigation options/ opportunities, which could meet both objectives of socio-economic development and climate protection. Ethiopia will identify and implement these options with the provision of financial, technical and technological support from developed countries. Potential areas/options for financial support, technology transfer and project development in GHG mitigation are

Energy sector

- Promoting use of renewable energy. Ethiopia could contribute to GHG mitigation by developing and exploiting her huge hydro, solar, wind, biomass and, geothermal energy resources not only for her own consumption but for neighboring countries as well;
- Replacement of diesel generators by hydropower mainly in urban centers;
- Substitution of photo voltaic (PV) lanterns for kerosene lighting;
- Improving/promoting energy efficiency and conservation e.g. wide dissemination of improved fuel wood and charcoal stoves, such as 'Mirt Mitad and Lackech';
- Promoting the use of fuels with low carbon content (fuel switching) e.g. exploiting the Ogaden natural gas reserve for various purposes including transport; and
- Use of gasohol (blending of ethanol with gasoline) for cars i.e. supply side management;

Land-use change & forestry sector

- Improving forest management practices;
- Protecting/preserving existing forests from loses by deforestation and other practices;
- Initiating new afforestation and reforestation programs;
- Rehabilitation of degraded forests; and
- Promoting agro-forestry;

Agriculture sector

- Improved nutrition through strategic supplementation and other methods;
- Treatment of forages to improve digestibility;
- Increasing productivity through improved genetic characteristics;
- Promoting sustainable agriculture;
- Promoting mixed crop livestock farming practices where appropriate;
- Promoting manure-management system facilities;
- Adopting appropriate fertiliser application;
- The use of conservation tillage techniques to sequester carbon in cultivated soils;
- Rehabilitation of overgrazed watering points and long-term settlement areas and redistribution of manure that is accumulated near these settlements;

Waste sector

- Integrated waste management;
- Composting solid waste of Addis Ababa city; and
- Landfill gas recovery from solid waste site of Addis Ababa city.

10. Implementation Strategy and Monitoring

Environmental degradation is a key issue in Ethiopia. In light of this the Environmental Protection Authority (EPA), an institution in-charge of environmental issues in general, is established at the federal level. The Environmental Policy of Ethiopia, an umbrella policy which is composed of 10 sectoral and 10 cross-sectoral environmental policies, was formulated in 1994. Environmental regulations and legislation are also formulated and submitted to the Government for approval. The EPA mainly assumes regulatory role and co-ordinates various activities within line ministries, agencies and non-governmental organisations. The Policy includes implementation issues like institutional co-ordination, legislative framework and monitoring, evaluation and review provisions. Among the 10 sectoral environmental policies one of them deals with Climate Change and Air Pollution. In this context, the NMSA is mandated to deal with this latter issue and implementation of Climate Change and Air Pollution issues falls under its responsibility.

Climate change issues are complex and their handling need multi-disciplinary approach. Continuity in the context of co-ordination will be the responsibility of the NMSA, but stakeholders will have specific responsibility. There is a need to maintain and strengthen the established Climate Change Steering Committee and the Expert Teams including the Climate Change and Air Pollution Studies Team of NMSA.

Chapter 1

INTRODUCTION

The atmosphere plays a key role in the exchange of radiation energy between the earth and the sun. It is known that the greenhouse effect or the heat trapping property of the atmosphere keeps the annual average surface air temperature of the earth at about 15 ^{o}C. Without this natural phenomena the earth's annual average temperature would be - 18 ^{o}C and life as we know it would not exist at such cold situation. This important function of the atmosphere is being threatened by the rapidly increasing concentration of greenhouse gases (GHGs) in the atmosphere as a result of human interference. At the present time about 7 billion tones of carbon are released annually into the atmosphere from the burning of fossil fuels and deforestation. Average annual global surface air temperature have increased by about 0.6 ^{o}C while sea level has risen by 10-25 cms over the last hundred fifty years and these increases have been partially attributed to the accumulation of GHGs in the atmosphere.

What is more worrying is the future. According to the Second Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), if steps are not taken to reduce emission of greenhouse gases (i.e. business as usual scenario continues), current mean annual global temperature is projected to rise by about 1 to 3.5 ^{o}C and mean sea level will rise by 15 to 95 centimetres before the end of the 21 century (IPCC, 1996). Such drastic change of climate and sea level rise in a short span of time is expected to have adverse impacts on many socio-economic sectors including low-lying areas and coastal wetlands, agricultural production, water supplies, human health and terrestrial and aquatic ecosystems. It is also expected that changes in the earth's climate will hit developing countries like Ethiopia first and hardest because their economies are strongly dependent on crude forms of natural resources and their economic structure is less flexible to adjust to such drastic changes. We have already seen, with natural phenomena such as hurricanes and droughts, the vulnerability of the development process to climate events.

It is against this background that in 1992 the world leaders reached an agreement to protect the earth's climate by signing the United Nations Framework Convention on Climate Change at the Earth Summit held in Rio de Janeiro. The ultimate objective of the UNFCCC is to stabilise the concentration of greenhouse gases in the atmosphere at a safe level.

Ethiopia participated at UNCED in 1992 and is signatory to UNFCCC. The country ratified the Convention in April 1994. The UNFCCC commits all Parties to develop and submit "national communications" which should contain inventories of greenhouse gas emissions and information on steps taken to implement the Convention at the national level. This National Report contains the required information and is presented following the guidelines of the UNFCCC for the preparation of Non-Annex I national communications.

Chapter 2

NATIONAL CIRCUMSTANCES

2.1 Geography

Ethiopia is located between approximately 3^0-15^0 N latitude and 33^0-48^0E longitude. The country covers a land area of about 1.12 million km^2, occupying a significant portion of the Horn of Africa. It shares boundaries to the east and southeast with Djibouti and Somalia, to the north with Eritrea, to the south with Kenya, and to the west with the Sudan.

Ethiopia is a country of great geographical diversity with high and rugged mountains; flat topped plateaux, deep gorges, river valleys and plains (Figure 2.1). This diversity in relief makes the country unique in Africa. Ethiopia is the most elevated part of Northeast Africa. The altitude ranges from the highest peak at Ras Dashen (4,620 meters above sea level), in Gonder, down to the Danakil depression (120 meters below sea level), one of the lowest dry land points on the earth, in the Northeast part of the country. The highlands (>1500 meters amsl) constitute around 45% of the total area of the country. In Ethiopia, all lands below 1500 metes in altitude are commonly classified as lowlands while lands above 1500 meters are classified as highlands. There is an essential difference between the highlands and the lowlands in terms of climate, population distribution, economic activities, lifestyle, etc.

Three major physiographic regions could be identified in Ethiopia. These are:

- The North, Central, and Southwestern Highlands and the associated Lowlands;
- The Southeastern Highlands and the associated Lowlands; and
- The Ethiopian Rift Valley.

The Ethiopian Rift Valley which is an extension of the Great East African Rift Valley divides the Ethiopian Highlands into two. There are a number of lakes along the floor of the Rift Valley.

The present land forms of Ethiopia i.e. mountains, plateaus, the Rift Valley, gorges, plains, etc were mainly formed during the Tertiary period of the Cenozoic era. These physical features are a result of a series of orogeny, volcanism, denudation, peneplantation, faulting and deposition over the years. Igneous, sedimentary and metamorphic rocks are all found in the country. Igneous rocks cover most of the Ethiopian Highlands.

Estimates show that about 87% of the country is covered by 11 major soil types. Some of these soil types including their percentage area coverage are Acrisols (8%), Cambisols (13%), Luvisols (6%), Lithosols (12.2%), Fluvisols (6%), Regosols (4%), Vertisols (10%), Xerosols (8.5%), Yermosols (3%), and Selonchakes (5%) (FAO, 1990).

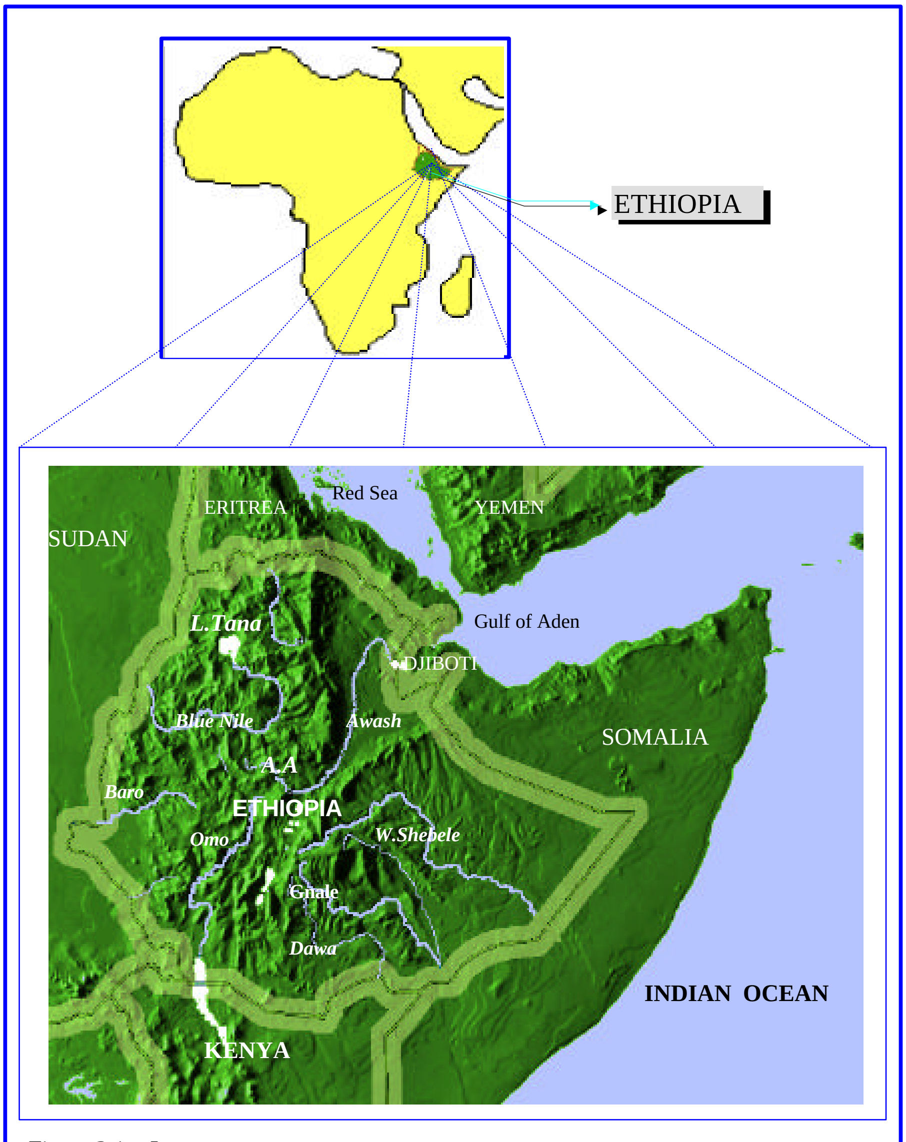


Figure 2.1: Locator map

2.2 History

Ethiopia is one of the ancient settlements and civilisations in the world. Ethiopia's history starts at Axum in the northernmost part of the country. Axum is the country's most ancient city and the capital of the historic Axumite Empire (4th Century B.C.). It is the site of remarkable monolithic stone stelae or obelisks. In its day, Axum was a commercial centre with its own currency and historical evidences show that trading took place with Egypt, Arabia, Persia and India. The country's cultural and architectural heritages include the 17th Century castles at Gonder (the then capital of Ethiopia), the rock hewn churches at Lalibella (one of the UNESCO treasures), the Sof Omar caves in Bale and 83 languages with over 200 dialects falling in four main language groups; namely, Semitic, Cushitic, Omotic and Nilo-Saharan. The modern capital of Ethiopia is Addis Ababa, which means "New Flower" in Amharic, located almost at the heart of the country. Emperor Menelik and Empress Taitu founded Addis in the turn of the 19th Century.

2.3 Population

The population of Ethiopia in 1994 (the base year for the Convention) was 53.5 million, the third largest in Africa after Nigeria and Egypt. Population density for 1994 was about 47 persons per square kilometres with a male and female composition of 50.3% and 49.7% respectively. Most of the population lives (about 85%) in rural areas. The Population of Ethiopia is increasing rapidly as shown in Figures 1.2 and 1.3. In 1999 it is estimated to reach 61.7 million (CSA. 1999). Currently growth rate of the population is 2.92%. The population is projected to increase to 129.1 million by the year 2030. Estimates show that the current population growth rate would decrease to 1.85% between 2025 and 2030.

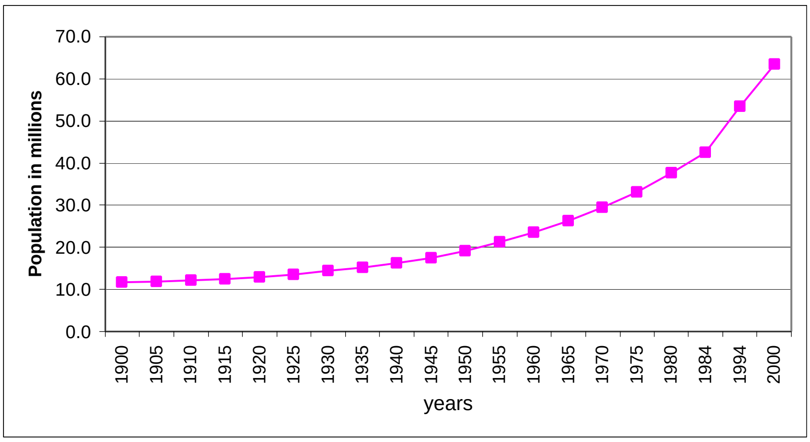


Figure 2.2: Population Growth over the Years (Sources: MEDaC, 1999 & CSA, 1998)

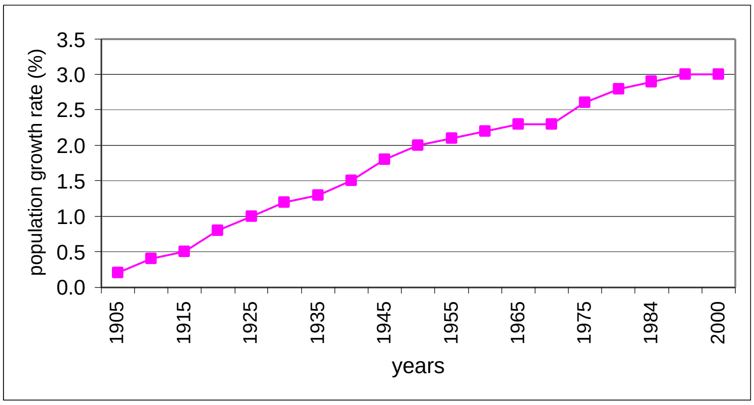


Figure 2.3: Population Growth Rate over the Years (Sources: MEDaC, 1999 & CSA, 1999)

The structure of Ethiopia's population reflects a high dependency ratio with about 45.4 % of the total population under the age of 15 years and 3.2% aged 65 and above. The total population at the age group 15-64 years is 27,271,605 (51.4%). Of this, about 79.0 % are economically active while the rest are economically inactive. Life expectancy at birth is estimated at 49.8 and 51.8 years for males and females respectively, the average being 50.7 years.

In 1994, of the total population of Ethiopia which is 10 years old and above, only 23% of both sexes were found to be literate. The literacy rate for urban and rural areas was found to be 69% and 15%, respectively for the same year (OPHCC and CSA, 1998).

2.4 Climate

The climate of the country is mainly controlled by the seasonal migration of the Intertropical Convergence Zone (ITCZ) following the position of the sun relative to the earth and the associated atmospheric circulation. It is also highly influenced by the complex topography of the country.

According to Koppen's climate classification system, Ethiopia has 10 climate types (Lemma Gonfa, 1996). The dominant climatic types are the Hot Arid Climate (Bwh), the Hot Semi Arid Climate (Bsh), Tropical Climate (Aw) with distinct dry winter, Tropical Monsoon Rainy Climate (Am) with short dry winter, Warm Temperate Rainy Climate (Cwb) with dry winter and Warm Temperate Rainy Climate (Cfb) without distinct dry season.

The traditional climate classifications of the country based on altitude and temperature shows the presence of five climatic zones namely: *wurch* (cold climate at more than 3000 Mts. altitude), *Dega* (temperate like climate -highlands with 2500-3000 Mts.), *woina dega* (warm- 1500-2500), *Kola* (hot and arid type, less than 1500m in altitude), and *Berha* (hot and hyper-arid type) climates. Classification with respect to rainfall regimes shows the presence of monomial, bi-modal and diffused pattern of rainfall climates. Consideration of the moisture index shows that large portion of the country falls under semi-arid and arid climates.

Mean annual rainfall ranges from about 2000 mm over some pocket areas in the Southwest to about less than 250 mm over the Afar lowlands in the Northeast and Ogaden in the Southeast. Rainfall decreases northwards and eastwards from the high rainfall pocket areas in the Southwest (Figure 2.4).

Rainfall during the year occurs in different seasons. Unlike most of the tropics where seasons are monomodal (one wet season), there are three seasons in Ethiopia, namely, Bega (October-January), a dry season, Belg (February-May), a short rain season, and Kiremt (June-September), a long rain season.

Temperatures are also very much modified by the varied altitude of the country. Mean annual temperature varies from about 10^0C over the high table lands over Northwest, Central and Southeast to about 35^0C over North-eastern edges (Figure 2.5).

Daily maximum temperature varies from more than 37 ^{0}C over the lowlands of Northeast (Afar Triangle) and Southeast (Ogaden) to about 15^0C over the highlands of Central and northern Ethiopia (Figure 2.6). Generally speaking the months of March through May are the hottest during the year.

Lowest annual minimum temperatures occur over the highlands particularly between November to January (Figure 2.7). Generally minimum temperatures that reach frost point during the Bega season are not uncommon over the highlands. Also temperatures lower than 5^0C occur during high rainfall months (July & August) over the plateaux in Northwest, Central and Southeast due to high cloud cover.

Based on the concept of growing period the country is classified into three major agro-climatic zones; namely:

- Areas without significant growing period,
- Areas with single growing period, and
- Areas with double growing period.

By combining growing period zones with temperature and moisture regimes, 14 agroclimatic zones have been identified in the country (NMSA, 1996).

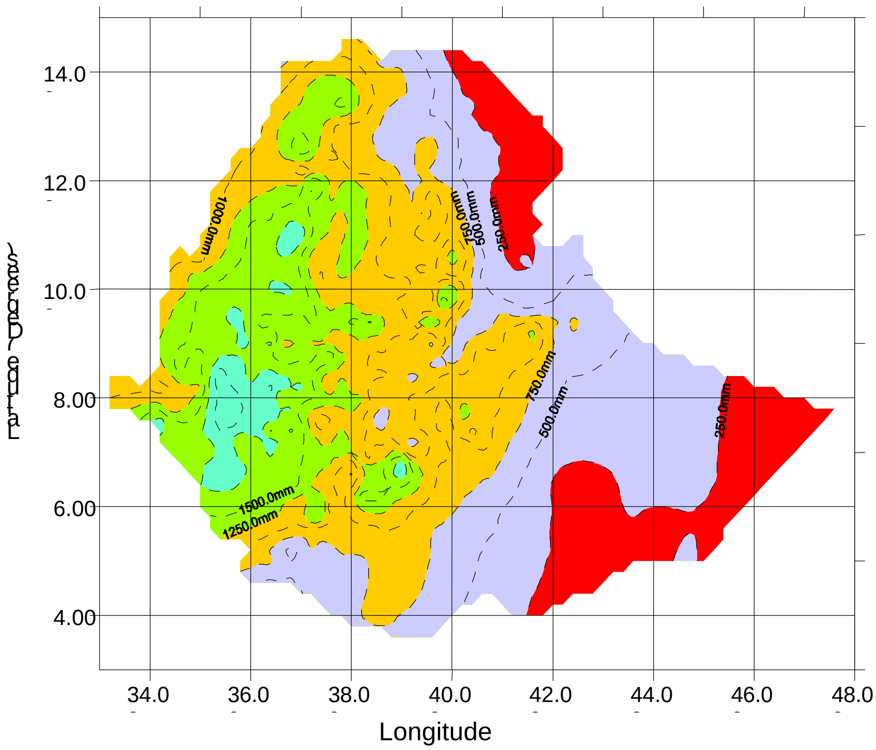
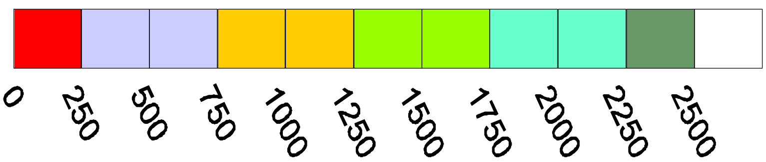


Figure 2.4 Cumulative Mean Annual Rainfall (mm)



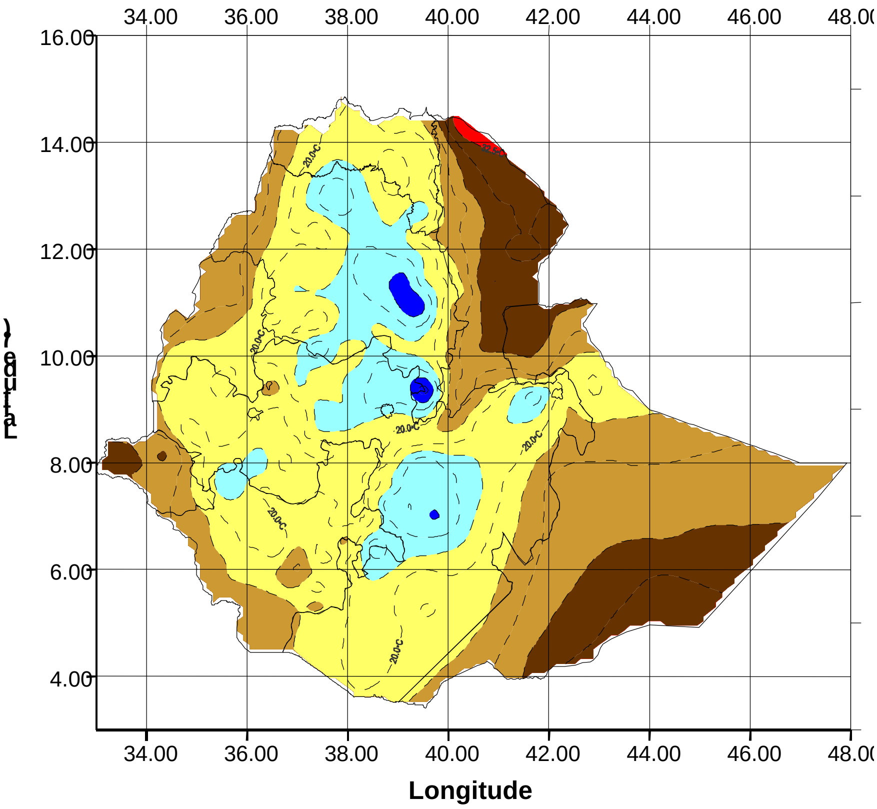
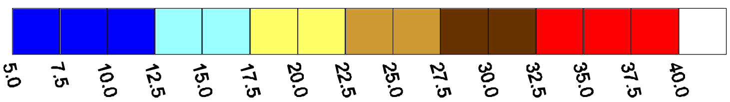


Figure 2.5 Daily Mean Temperature for the Year (°C)



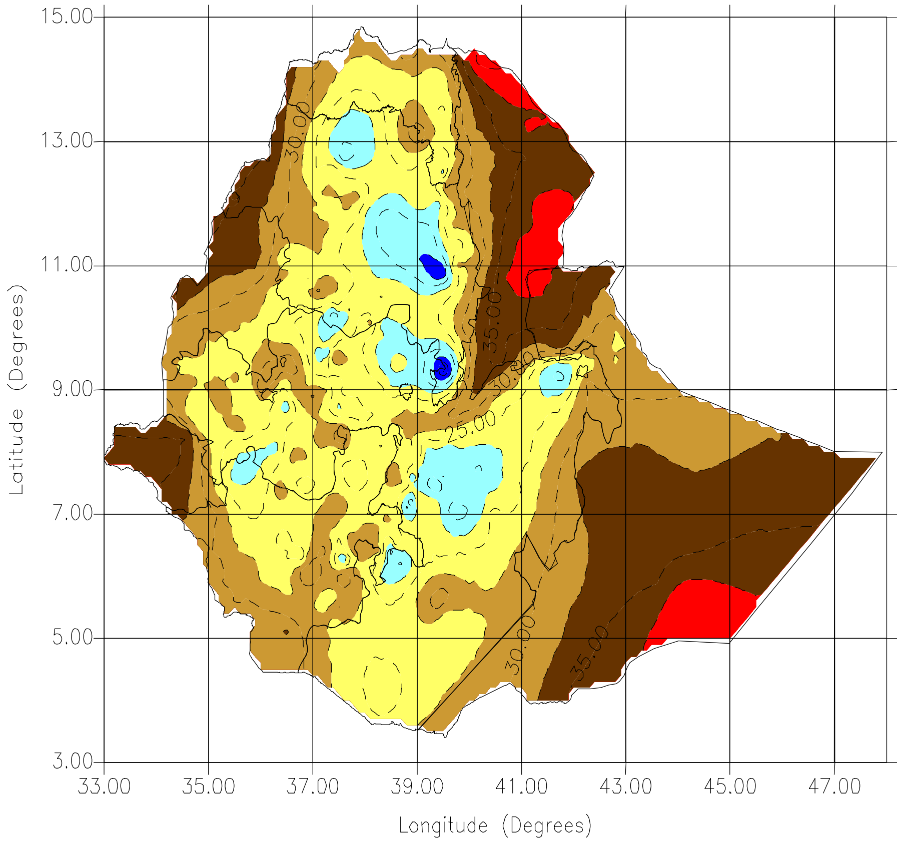
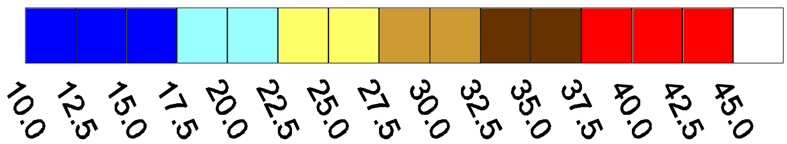


Figure 2.6: Daily Maximum Temperature for the Year (°C)



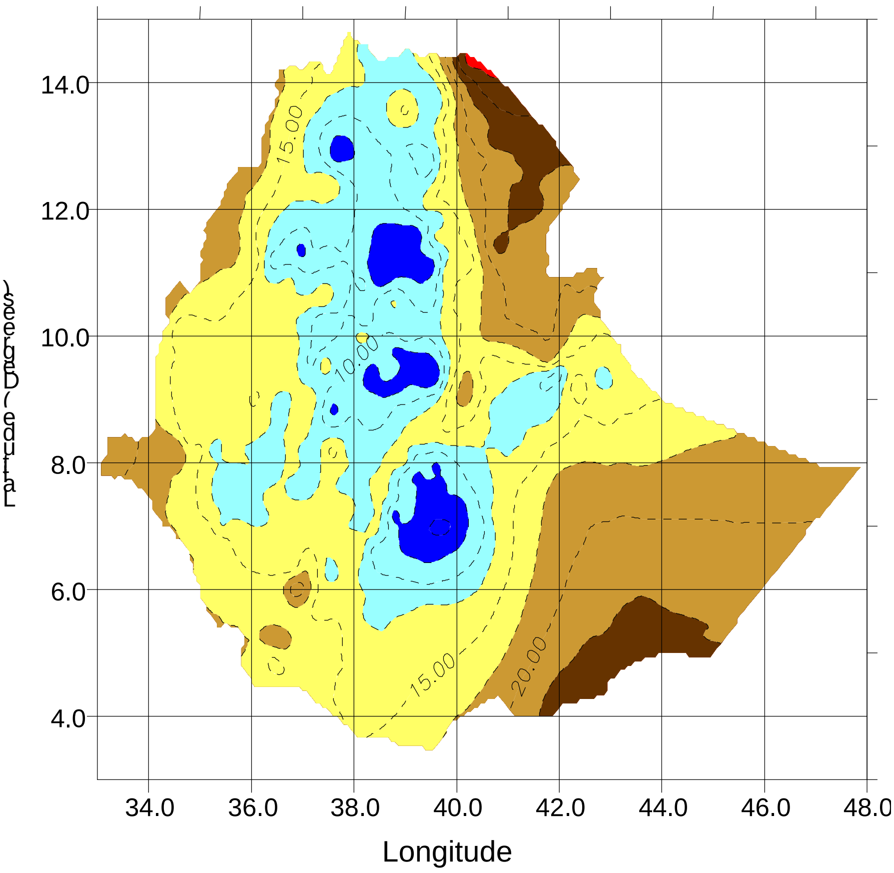
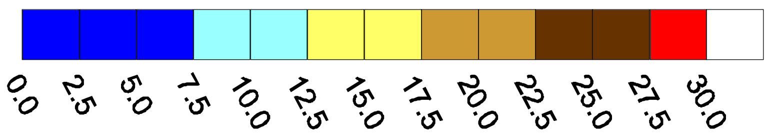


Figure 2.7: Daily Minimum Temperature for the Year (°C)



2.5 Economy

Ethiopia is one of the least developed countries in the world. The gross domestic product (GDP) in 1994 was USD 6108.60 million at factor cost (in constant 1980 dollars) and per capita income of just under USD120.00. Real GDP grew by 5.4% in 1994. The growth rate of GDP (at current market price) on average was 6.0%, 9.1% and 11.1% during the period of 1980/81-1990/91, 1980/81-1997/98 and 1992/93-1997/98 respectively (MEDaC, 1999). The economic reform made after the political change in 1991 has brought some improvement in the Ethiopian Economy. The major export items of the country include **c**offee, hides, oilseeds, beeswax, sugarcane, etc.

The country's economy is heavily dependent on agriculture for generating employment, income and foreign currency. The dominant sectors and their contribution to GDP in 1994 were agriculture (49.7%), industry (11.2 %) and services (39.1%). Such high dependence of the economy on agriculture could add an additional factor to the vulnerability of Ethiopia to climate change.

The trend in real gross domestic product (at 1980/1981factor cost) and the sectoral shares is shown in Figure 2.8. The share of the agricultural GDP is consistently high. The annual growth rate of real GDP in Ethiopia since 1981/82 along with growth rate of the agricultural GDP is also shown in Figure 2.9. There has been significant fluctuation in the annual GDP growth rate. One of the major causes for the fluctuation in real GDP growth rate is climate variability, which directly affects agriculture**.**

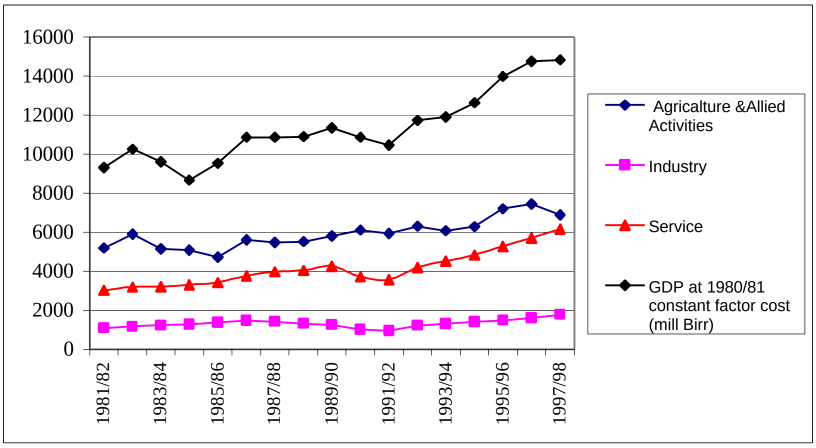


Figure 2.8: Trend in Sectoral and Total GDP (Source: MEDaC, 1999, Survey of the Ethiopian Economy)

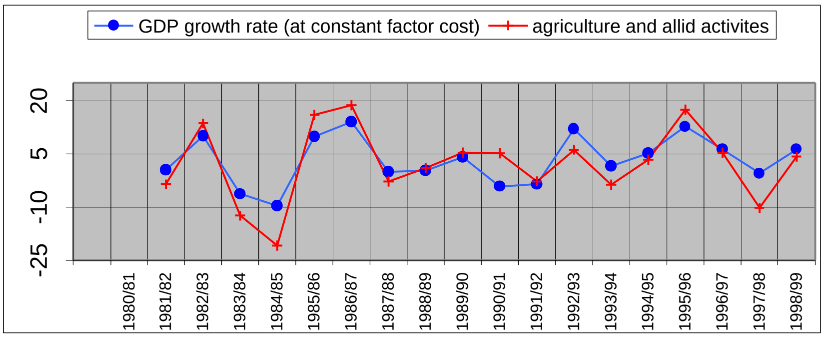


Figure 2.9. Annual Growth Rate of Real GDP in Ethiopia along with Growth Rate of the Agricultural GDP

2.6 Land Use/ Land Cover

Ethiopia's complex topography is one of the major factors for the existence of a variety of environmental features ranging from semi-desert to alti-montane. Despite the complexity of the topography it has generally become a common practice to classify the country into lowland areas (< 1500 meters amsl) and highland areas (>1500 meters amsl). The heterogeneity of the land resource endowments has resulted in a number of diverse agro-ecological conditions. 12 major geomorphologic units and 70 subunits, 18 soil associations, 6 climatic and edaphic vegetation associations, 6 rainfall patterns, 10 thermal zones, 14 length of growing period zones and 14 production regions have been delineated (Ermias Bekele, 1987). The existence of 15 land use patterns, 48 cropping patterns, 19 livestock patterns and at least 6 farming systems have also been identified.

However the major land use forms are grazing and browsing, cultivation and forests and woodlands. More than 50% of Ethiopia's land is utilised for grazing and browsing. It has to be noted here that grazing and browsing occurs in cultivated areas, in woodlands and forests, bushlands, shrub lands, grasslands and in un utilisable lands. Cultivation forms the second largest (nearly 23%) land use while forests and woodlands cover about 7 percent of the country. Over 16% are bare land, in the form of exposed rock, salt flats and sand. Table 6 shows the distribution of land use in the country (EMA, 1988).

2.7 Agriculture

Agriculture which includes crop production, animal husbandry livestock, forestry, fisheries and apiculture remains by far the most important sector of the country for the following reasons. It directly supports about 85% of the population in terms of employment and livelihood. It contributes about 50% of the country's gross domestic product (GDP). It generates about 90% of the export earnings. It supplies around 70% of the raw material requirement of ago-based domestic industries (MEDaC, 1999). Agriculture is also the major source of food for the population of the nation and hence the prime contributing sector to food security. In addition agriculture is expected to play a key role in generating surplus capital to speed up the overall socio-economic development of the country.

Table 2.1: Landuse Distribution in Ethiopia.

Use	Percent of the total area of the country
Intensively cultivated land	10.3
Moderately cultivated land	12.5
Afro-alpine and sub-afro-alpine vegetation	0.2
High forest	4.4
Woodland	2.5
Riparian wood land and shrub	0.6
Bush land and shrub land	21.4
Grass land	30.5
Water bodies	0.5
Others	17.5

Source: Ethiopian Mapping Authority (EMA), 1988.

Ethiopia is believed to have a considerable land resource for agriculture. About 73.6 million hectare (66%) of the country's land area is estimated to be potentially suitable for agricultural production (MEDaC, 1999). It is generally accepted that this land resource can support a large population by providing enough food and other agricultural products required for the development of other sectors. However the country has remained unable to feed its people for many years due to backward agricultural practices and climate variability.

.

The farming system in Ethiopia can be classified into five major categories namely the highland mixed farming system, the lowland mixed agriculture, the pastoral system, shifting cultivation and commercial agriculture (Befekadu Degefe, etal, 1999/2000). The highland areas (above 1500 meters) constitute about 45% of the total area and are inhabited by four–fifths of the population. The highland areas also support about 70% of the livestock population.

According to MEDaC crop production is estimated to contribute on average about 60%, livestock accounts around 27% and forestry and other sub-sectors around 13% of the total agricultural value.

The agriculture sector is dominated by small-scale farmers who have been adopting low input and low output rain-fed mixed farming with traditional technologies. The present government of Ethiopia has given top priority to the agricultural sector and has taken a number of steps to increase productivity in this sector.

The strong dependence of the country on agriculture, which is very sensitive to existing climate variability, is a cause for concern as climate variability would change as a result of the expected climate change.

2.7.1 Crop Production

The existence of diverse agro-ecological conditions enables Ethiopia to grow a large variety of crops including Cereals (teff , maize, wheat, barley , millet, oats, etc), Pulses (horse beans, field peas, lentils, chick-peas, haricot beans, vetch, etc), Oil Seeds (linseed, niger-seed, fenugreek, rapeseed, sunflower, castor bean, groundnuts, etc), Spices & Herbs (pepper, garlic, ginger, mustard, etc), Stimulants (coffee, tea, chat, tobacco, etc), Fruits(banana, orange, grape, papaya, lemon, menderin, apple, pineapple, mango, avocado, etc), Sugarcane, Fibres (cotton, sisal, etc), Vegetables (onion, tomato, carrot, cabbage, etc), Root and Tuber crops (potato, enset, sweet- potatoes, beets, yams, etc).

The production of crops is dominated by small scale subsistent farmers (about 8 million peasant household heads). These small scale farmers on average account for 95% of the total area under crop and for more than 90% of the total agricultural output. Most of the food crops (94%) and coffee (98%) is produced by small scale farmers while the remaining 6% of food crops and 2% of coffee is generated from commercial farms (state and private). Most farmers still practice traditional way of farming i.e. ploughing the land with oxen-drawn wooden ploughs with steel pikes, low inputs of fertiliser, pesticide and improved seeds.

It is estimated that 16.5 million hectares (14.8% of the country) is under cultivation most of which (about 88%) is covered by annual crops and the remaining being under perennial crops. The coffee area is estimated to be half a million hectares. Cereals account for the major part (> 80 %) of the total cultivated area followed by pulses. Estimation of the total cultivated area and production of cereals, pulses and oil seeds over the years is provided in Table 2.2.

The 1994 agricultural sample survey indicates that the average yield of all crops at the national level was about 10 quintals per hectare while the average yield of cereals, pulses and other crops was about ten, nine and three quintals per hectare respectively (CSA, 1995).

The performance of crop production has been poor for the last three and half dakedes. Food grain per capita had registered a downward trend for several years. The country, which had once been self-sufficient in food production and a net exporter of food grains has become a net importer of grain since 1981/82 (MEDaC, 1999).

Table 2.2: Estimates of Area Cultivated and Production of Major Crops by Private Peasant Holdings (both seasons).

		Area cultivated (in 000' hectare)				Production (in 000 Quintals)			
Year	Crop type	Cereals	Pulses	Oilseed	**TOTAL**	Cereals	Pulses	Oilseed	**TOTAL**
Eth Cal	G.C								
1973	1980/81	4504	725	181	**5,410**	55122	9017	1262	**65,401**
1974	81/82	4362	767	212	**5,341**	51994	8154	865	**61,013**
1975	82/83	4776	780	246	**5,802**	65668	9563	1303	**76,534**
1976	83/84	4422	737	232	**5,391**	57152	7012	1040	**65,204**
1977	84/85	4554	739	264	**5,557**	38727	4838	1046	**44,611**
1978	85/86	4667	668	275	**5,610**	44278	4605	1153	**50,036**
1979	86/87	4647	599	208	**5,450**	62775	5741	1089	**69,605**
1980	87/88	4915	729	185	**5,830**	59570	5640	881	**66,091**
1981	88/89	NA	NA	NA	**NA**	57472	5953	891	**64,316**
1982	89/90	4851	628	221	**5,700**	61383	6749	983	**69,115**
1983	90/91	4199	702	244	**5,145**	57131	9968	3141	**70,240**
1984	91/92	4087	683	237	**5,008**	55603	9702	3057	**68,362**
1985	92/93	7741	1033	373	**9,146**	70639	8425	1240	**80,304**
1986	93/94	6108	867	322	**7,297**	61912	7501	1107	**70,520**
1987	94/95	6449	920	342	**7,710**	65891	7947	1172	**75,010**
1988	95/96	7671	1006	394	**9,071**	92654	8662	1963	**103,279**
1989	96/97	7437	1012	485	**8,934**	93591	8609	2168	**104,368**
1990	97/98	6620	939	416	**7,975**	74345	7325	1815	**83,485**

Source: Central Statistical Authority (CSA, various issues) and adopted from MEDaC, 1999
1 quintal= 100 kilograms, NA: not available

Inappropriate polices, declining farm size and subsistence farming because of population growth, land degradation due to inappropriate use of land such as cultivation of steep slops, over cultivation, overgrazing, devegitation and recurrent drought are the major causes for the poor performance of crop production. Other issues and factors that contribute for the low productivity of crop production include tenure insecurity, weak agricultural research and extension services, lack of agricultural marketing, inadequate transport network, low level use of fertilisers, improved seeds and pesticide as well as the use of backward technologies of farm implements.

The present government of Ethiopia has given top priority to the agricultural sector and has taken a number of steps to increase productivity in this sector. As a result of this crop production has shown some improvement since 1994.

2.7.2 Livestock

Ethiopia has the largest livestock population in Africa and the tenth largest in the world. Livestock is an integral part of the farming systems in the country. It is the source of many social and economic values such as food, draught power, fuel, cash income, security and investment in both the highlands and the lowlands/pastoral farming systems.

The livestock sector contributes approximately 12 to 15% to the overall or total GDP and about 25 to 30% to the agricultural GDP (MEDaC, 1999). It is also a major source of foreign exchange next to coffee.

In general the livestock resource of the country is characterised by low productivity levels. Average yields per animal slaughtered or milked are estimated to be 110 kg of beef, 10 kg of mutton and 213 kg of cow's milk. Egg production from indigenous poultry is between 55 to 80 per annum with an average egg weight of 45 kg. Livestock production growth rates are very small and lagged behind population growth, which is increasing at a higher rate. Thus there is a decline in per capita consumption of livestock products. At present the per capita consumption of milk and meat is estimated to be 16 kg and 10 kg per annum respectively. This puts Ethiopia at the least level even from its neighbouring countries.

Table 2.3: Number of Livestock Population ('000 Heads)

Year (GC)	Cattle	Sheep	Goats	Horses*	Asses*	Camels*	Mules*	Poultry*
1980/81	27,000	23,221	18,769					
1981/82	27,461	23,867	19,123					
1982/83	27,929	24,531	19,483					
1983/84	28,406	25,213	19,850					
1984/85	28,220	24,256	18,896					
1985/86	27,470	22,103	17,020					
1986/87	27,939	22,718	17,341					
198788	28,415	23,350	17,668					
1988/89	28,900	24,000	18,000					
1989/90	29,393	24,668	18,340					
1990/91	29,894	25,354	18,685	2,700	5,100	1,060	610	58,000
1991/92	30,404	26,059	19,037	2,750	5,200	1,070	630	59,000
1992/93	30,923	26,783	19,396	2,750	5,200	1,000	630	54,000
1993/94	31,450	27,527	19,762	2,750	5,200	1,000	630	54,000
1994/95	31,985	28,243	20,133	2,750	5,200	1,010	630	55,000
1995/96	32,624	28,977	20,512	2,750	5,200	1,020	630	55,000
1996/97	33,293	29,760	20,898	2,750	5,200	1,030	630	55,000
Annual average Growth rate (%)	1.2	1.4	0.5					

Sources: (MECDaC, 1999) & (*FAO Production Year Books, Vol. 45-51, 1991-1997)

Inadequate feed and nutrition, low level of veterinary care, occurrence of diseases, poor genetic structure, inadequate budget allocation, limited infrastructure, limited research on livestock, land tenure and recurrent drought are the main constrains in this sub-sector (Befekadu,Degefe, etal, 1999/2000).

2.7.3 Fisheries

Information on Ethiopia's fishery resources are scarce. According to different sources annual fish production potential from country's fresh water bodies (lakes, rivers and reservoirs) has been estimated to fall in the range of 35,000 to 60,000 tons (MEDaC, 1999; UNCED National Report, 1992; Woldemeskel G. Mariam, 1998) of which less than 15% is presently being exploited. About 100 species of fish, among which 4 are endemic, are known to exist in the fresh water bodies of the country. Tilapia, Nile Perch, Cat Fish, Lates, Bargus, Claries and Labeo are the most important fish species for commercial production (MEDaC, 1999; UNCED National Report, 1992).

2.7.4 Forestry

According to the 1992 Ethiopian Forestry Action Plan (EFAP) report the forest resources of the country including natural high forests, woodlands, bushlands and plantations reach about 27 million hectares (Table 2.4).

Table 2.4: Estimates of the Area, Growth Stock, and Incremental Yields in 1992

Forest resource	Area (million ha)	Growth stock (meter cube/ha)	Annual incremental yields	
			per unit area (meter cube/ha/y)	total (million meter cube)
Natural forests	2.3	-	-	0.3
-slightly disturbed	0.7	90-120	5-7	-
-heavily disturbed	1.6	30-100	3-4	-
Woodland	5.0	10-50	1-2	6.4
Bushland	20.5	5-30	0.2	4.0
Plantations	0.2	-	9.9-14.4	1.6

Source: (EFAP, 1994)

Forest plantation resources are estimated to be 200,000 ha out of which 95, 000 ha are industrial plantations, 35,000 ha are peri-urban plantations and 70,000 ha are community woodlots.

The major categories of forest products include fuelwood, industrial wood and construction wood. Sawn wood, plywood, fibreboard and particleboard and paper are the primary industrial wood products. It is known that industrial wood consumption per capita in Ethiopia is one of the lowest in the world.

Ethiopian forests also provide a wide variety of non-wood products such as incense, gum arabic, medicinal plants, foodstuffs, honey, etc. The annual production of incense and gum is estimated to reach 1500 tones out of which about 50% is exported.

In the EFAP report it is estimated that forests and woody vegetation are disappearing at a rate of 150,000 to 200,000 ha annually. It needs to be noted that the available information on the country's forest resources, location, extent, volume of the standing growth stock, annual growth rate and rate of depletion of are scarce and sometimes inconsistent. It is expected that the on-going Woody Biomass Inventory and Strategic Planning Project

(WBISPP) being carried out by the Ministry of Agriculture (MoA) will provide up-to-date and reliable information on the woody biomass resources of Ethiopia.

2.7.5 Apiculture

Ethiopia has the largest bee population among African countries by having about 10 million bee colonies. The annual honey and beeswax production has been estimated at 3,300 and 3,500 tons respectively and this makes Ethiopia one of the eight countries with the highest production in the world. About 10% of the annual honey and beeswax production is exported for world market while the rest is consumed domestically (MEDaC, 1999; UNCED National Report, 1992; Woldemeskel G. Mariam, 1998). Bee keeping is mainly carried out by small-holder farmers using traditional hives. The modern beehive production capacity per harvesting season is 15 to 20 kg of honey while the traditional one is about 5 kg per season.

2.8 Biodiversity and Wildlife

Ethiopia is rich in biodivrsity with high endemism. The richness in flora and fauna is a reflection of the diverse ecological setting, climate and topography found in the country. The Ethiopian flora is estimated to contain 6500 to 7000 species of higher plant, of which about 12% are endemic (Tewolde Berhan Gebre/Egziabher, 1991). Ethiopia has the fifth largest flora in tropical Africa (Brenan, 1978). The country is also one of the 12 Vavilov centres due to its crop genetic diversity (UNCED National Report, 1992).

The country is also very rich in faunal diversity with a large number of endemic species. Out of 277 terrestrial Ethiopian mammals, 31 are endemic of which 20 are highland forms. For birds, 862 species have been recorded in Ethiopia, 16 of these are endemic to the country and another 14 are endemic to Ethiopia and Eritrea (EWNHS, 1996). Of these endemic species 19 birds occur above 1,000 m amsl. This is a higher rate of avian endemism than any other country in mainland Africa. Though data on vertebrate groups are sparse it is estimated that there are 201 species of reptiles (10 endemic) and 63 species of amphibians (34 endemic) in the country. Ethiopian vertebrates include 9 endemic species and at least 15 non-endemic species, which are considered threatened.

Birds have proved to be excellent indicators of biodiversity or productivity in breeding, migrating and wintering areas because they are easily seen and are relatively well known as compared to other animals. Of the 862 bird species so far recorded in Ethiopia, 261 species or 30.2% are species of international concern. According to EWNHS there are 31 globally threatened species recorded from Ethiopia. Ethiopia also holds 5 endangered, 12 vulnerable, and 14 near threatened species. Fifty sites in Ethiopia are visited regularly by one or more globally threatened species. If one of these important areas in Ethiopia is damaged by the expected climate change the effect would be global. Ethiopia has the following three globally recognized Endemic Bird Areas (EBAs) from the 63 sites recognized as Important Bird Areas of Ethiopia namely Central Highlands, Southern Highlands and Juba -Sheballe Valley (EWNHS, 1996).

The existing protected areas network of Ethiopia is extensive and covers the majority of important habitats. Currently there are 9 national parks, 3 sanctuaries, 8 reserves and 18 controlled hunting areas covering a total area of about 192, 000 Km^2 (Fetene Hailu, 1999).

The immediate and major threat to the conservation of protected areas in Ethiopia is human encroachment. Habitat destruction/fragmentation, introduction of alien species, pollution, and overexploitation of wildlife and their habitat beyond its limit of regeneration are all on the increase due to factors such as population pressure, poverty, poor management and lack of awareness. Within the protected areas degradation due to human disturbance and exploitation continues to occur. Large declines in wildlife numbers especially in non-protected areas is being observed as well. Climate change would put an additional stress on wildlife and biodiversty of the country. Besides the management of the existing national parks, sanctuaries, reserves and controlled hunting areas of the country is very weak due to lack of capacity.

2.9 Energy

2.9.1 Energy Resources

Ethiopia is endowed with various energy resources. The gross hydro-energy potential of the country is about 650 terawatthours (TWh) per year, of which 25 percent could be exploited for power production (CESEN, 1986). This enormous potential ranks Ethiopia as one of the world's leading countries in hydro potential. The most promising hydropower development potential is found in the Blue Nile, Omo and the Wabi Shebelle river basins (MEDaC, 1999). Between 30 and 50 billion cubic metres of natural gas, more than 1000 MW of geothermal power and several hundred million tons of coal and oil shale also constitute the energy potential of the country so far discovered (Hailu G.Mariam, 1992) . The total solar radiation reaching the territory is 2.3 TWh per year while wind energy potential is estimated at 4.8 million Tcal per year (CESEN, 1986). The country's woody biomass energy resources is about 14 million Tcal in standing stock and 0.93 million Tcal in terms of annual yield. The annual agricultural waste available for energy is about 176, 000 Tcal per year. Although the country has abundant energy resources it is not yet well developed due to lack of capacity and investment. For example only less than 1% of the total hydropower potential of the country is known to have been utilised so far.

2.9.2 Energy Production and Consumption

The energy sector in Ethiopia is composed of three main sub-sectors: biomass, petroleum and Electricity. Energy demand (consumption) of the country is satisfied by wood fuel (77%), dung (7.7%), crop residue (8.7%), Bagasse (0.06%), charcoal (1.15%), electricity (1%), liquid petroleum gas (LPG) (0.05%), and oil products (4.8%). This implies that about 95 per cent of the energy supply of the country comes from biomass sources where as petroleum and hydro-electricity constitute the bulk of the modern energy supply source, with petroleum accounting for the lion's share (about 4%) and electricity supplying about 1%. The National

Energy Balance for 1995/96 depicting energy supply and consumption is provided in Annex IV.

Petroleum is wholly imported and mainly used in the transport sector. However, kerosene may soon rate as a major petroleum fuel consumed outside the transport sector owing to the rising demand in the household sector. Petroleum imports have consumed about 30 % of the total export earnings of the country in recent years.

2.9.3 Biomass Fuel Consumption

Traditional biomass fuels such as woody biomass, agricultural residue, charcoal and dung are the dominant energy sources of Ethiopia. Biomass fuels are mostly consumed by domestic sector followed by cottage industries. The household sector accounts for about 93 % of the biomass fuel consumption and there are ample signs of shortages of fuel wood in both urban and rural areas. Household cooking depends to a large extent on fuelwood. The contribution of fuel wood in supplying energy for commercial activities (food catering and cottage industries) is also significant.

In Ethiopia it is estimated that approximately 38 million metric tones of fuel wood was consumed in 1995/96[1]. The average daily consumption of fuel wood by Ethiopian households is estimated to be approximately 2kg per capita[1], but actual consumption varies considerably by region. In the northern part of the country, where natural forest is non-existent, consumption is relatively low. On the other hand daily consumption rates in the south - west forested areas could be as high as 5 kg per capita.

As noted above the predominant demand for fuel wood comes from households, which accounts for an estimated 93.4% of total use. Food and beverages, cottage industries and small and medium scale industries use 3.7%, 2.7% and less than 0.2% respectively. Because of the scarcity of woody biomass fuels, growing numbers of people are forced to use a variety of agri-residues as alternative fuels for cooking. Agri-residues include wheat straw, stalks, corn cobs, green crop residues etc.

Cattle are the major source of dung in Ethiopia. The amount of dung produced annually was estimated on the basis of the number of animals and typical dry weights of dung per head of different types of animals.

There is a great loss of energy in producing charcoal by the widely practiced earth-mound kiln technique. Approximately 6% of the gross supply of wood are converted to charcoal. Charcoal use in urban households is dominant compared to rural areas. It is also widely used in cottage industries, small, medium and large scale industries.

2.9.4 Fossil Fuel Consumption

Although Ethiopia is highly dependent on traditional energy sources to meet its energy requirements, some economic sectors like the transport sector are fully dependent on

[1] National Energy Balance (1990/91 & 1995/96)

modern energy sources, mainly on petroleum products. The use of diesel oil for the production of electricity is overwhelmingly dominant in areas/ towns, which are far from the national grid. The use of secondary fossil fuels in industries and their use in the commercial or services sector is also relatively significant. Demand for kerosene in the household sector is also growing fast and it may become a major petroleum fuel consumed outside the transport sector.

In the Ethiopian context, Energy industries include those entities which produce electricity by using fuel oil/ diesel as a raw material. Though the method is traditional, carbonisation of wood to produce charcoal could also be considered as part of the energy industry. Among manufacturing industries and construction, large and medium scale industries such as the textile and beverage are the major consumers. Road construction as part of the construction industry, is expected to consume the greater share, even though statistical information is scarce. Residential sector uses fossil fuels such as Kerosene, Diesel and LPG mainly for cooking and lighting purposes. Agriculture, forestry and fishing use fossil fuels for mechanised farming / land preparation and for boats during fishing practice. The Commercial and Institutional sector comprises of government offices, hotels, restaurants snacks and other recreational facilities which operate using either fossil or biomass energy sources.

Solid fossil fuels like cooking coal, steam coal, lignite, sub-bituminous coal and peat, which are categorised as primary solid fossil fuels and coke (secondary solid fossil fuel) are not used for energy supply in Ethiopia. Therefore, there is no need to look at GHG emissions from these fuels at present. However research and studies are being carried out by the Ministry of Mines and Energy on the utilisation of the available deposits of lignite and sub-bituminous coal as an indigenous sources of energy and exploitation and use of these deposits might become sources of GHG emissions in the future.

Petroleum is wholly imported and consumes a significant portion (about 30 %) of the total export earnings of the country in recent years. The volume of extensively used liquid fossil fuels utilized for energy supply refined from imported crude oil and secondary fossil fuels over the years is given in Tables 2.5 and 2.6.

2.9.5 Electricity

The Ethiopian Electric Power Corporation (EEPCO) is a public utility organisation responsible for generating, transmitting, distributing and selling of electricity in the country. EEPCO maintains two types of electrical systems; namely: the interconnected system (ICS) and the self contained systems (SCS) which consists of major hydropower plants and mini-hydros plus a number of isolated diesel generating units respectively.

To date, the aggregate electricity generated is a mere 1.2 billion KWh/a, which is less than one percent of the potential. The ICS consists of six hydros (Koka, Awash II, Awash III, Fincha, Melka Wakena and Tis Abay) and three diesel powered plants with total installed capacity of 371.6 MW and 9.0 MW respectively in 1995/96.

Table 2.5: Volume of Refined Products of Assab Refinery from Imported Crude Oil 1983-1997 in Metric Tones (MT)

Year	LPG	Gasoline	Jet Kerosene	Gas/ Diesel Oil	Residual Fuel Oil (CSTS)	Residual Fuel Oil (180 CSTS)	Bunker Fuel Oil	Bitumen	Marine Diesel Oil
1983	5407	102922	53097	204982	82994	222468	4418	15774	3998
1984	5283	102836	54320	200690	93560	20339	5119	13735	4050
1985	5258	100256	54711	184361	101940	188101	8765	11178	5580
1986	6043	110332	59258	195247	110703	197993	10671	12721	4742
1987	5908	110038	62898	190830	111692	200096	11063	13595	3028
1988	5869	110122	66563	186054	118835	201620	13308	10496	2750
1989	6120	113622	64492	195130	113836	221881	14696	9279	1688
1990	4377	84366	51348	141768	74949	166779	10458	7628	952
1991	2684	52338	36582	91631	38977	107374	6825	3552	1429
1992	3396	59040	37475	118157	58823	137783	7669	6355	1506
1993	5344	84157	52031	170178	101216	177667	8926	15069	484
1994	5836	87246	49964	180371	118032	144254	10503	16147	
1995	5656	82403	44861	177435	129061	153097	9000	17391	
1996	5688	82963	45523	177656	141030	135241	7663	21414	
1997	2872	46859	24430	94065	80246	69232	3913	10283	

Source: - Ethiopian Petroleum Enterprise (EPE)

Table 2.6: Volume of Imported Petroleum Products 1982-1997 (MT)

Year	Crude Oil	Gasoline	Jet Kerosene	Other Kerosene	Gas/Diesel Oil	Residual Fuel Oil (80 CSTS)	LPG	Avgas	Lubricant
1982	740,500	13,959	19,281	10,219	84,500				
1983	772,500	16,737	21,789	15,211	81,000				
1984	743,500	30,197	11,017	27,794	109,462				
1985	718,496	27,987	41,510	35,924	144,156				
1986	783,990	10,277	61,678	42,841	171,142				
1987	772,603	14,786	51,636	55,637	189,945				
1988	760,410	16,444	46,612	67,304	196,276		2,044		
1989	794,642	8,802	53,307	74,304	191,182				
1990	649,443	10,247	61,088	52,626	184,864			648	9,752
1991	453,016	31,573	39,047	39,900	206,093	13,367	833	100	10,200
1992	474,115	41,121	23,952	70,577	238,115	1,100		459	14,746
1993	666,616	29,085	10,270	107,503	237,056			307	11,540
1994	713,820	36,335		134,555	264,256			186	11,758
1995	659,940	59,297	11,600	159,463	320,403		603	196	8,272
1996	668,849	71,366	16,588	183,377	374,783			247	13,084
1997	380,754	89,436	19,682	196,470	433,571	50,000	1,700	297	12,386

Source: - Ethiopian Petroleum Enterprise (EPE)

The SCS is comprised of three mini hydros and several diesel powered plants distributed in different parts of the country with an aggregate capacity of 38.2 MW (MEDaC, 1999).

On average industry and the residential (domestic) sectors account for about 44% and 43% of the national electricity consumption respectively in recent years while the commercial sector accounts for 12 %. The remaining part of the electricity is consumed by street lights and other purposes. Demand for electricity is growing fast particularly in the residential sector. Currently there are ongoing projects and plans to produce hydro-electricity to meet the demand.

2.10 Transport

Ethiopia's conventional transport system is comprised of a road network consisting of 23,812km of classified roads, a single gauge railway line running for a distance of 781 kms from Addis Ababa to Djibouti, two international airports and thirty domestic airports. There are also eleven ships and vessels operating along the routes to western Europe, the Middle and Far East with gross and net registered tonnage of over 60,000 and 30,000 respectively.

The transport sector shares a large volume of capital investment in Ethiopia. Although the contribution of the transport sector to the total GDP is small (about 6%), the sector plays a crucial role in supporting agricultural development, adoption of an outward-oriented trade strategy and domestic competitiveness. The transport services are generally not accessible to the large majority of the rural population and hence there is heavy dependence on walking, head loading and traditional means of transport using pack animals.

Development of surface transport in Ethiopia has been seriously limited by various factors such as wide topographical variations, extremely rugged terrain, severe climatic conditions and a widely dispersed population. These factors make construction of transport infrastructure not only physically difficult but also extremely costly.

The road transport plays a major role in the movement of goods and passengers as compared to other modes of transport. The road density is among the lowest in Africa which is 21 km per 1000 km^2. According to the 1997 Vehicle Inspection and Registration Data there were 102,880 operational vehicles in the country (Table 2.7).

.

The transport sector is a major user of fossil fuel in the country and accounts above 50% of the total fuel consumption. The volume of fuel consumed by road transport vehicles in Ethiopia, which forms the grater share with such low level of vehicular travel as compared to other countries, can be considered a concern to local population but hardly a current challenge.

Table 2.7: Total Operational Vehicles Inspected & Registered (1990-1997)

No.		1990	1991	1992	1993	1994	1995	1996	1997
1	CARS	31,815	30,988	33,656	35,771	41,991	41,814	44,428	52,131
2	LIGHT DUTY TURCkS	12,372	14,041	12,268	12,878	10,154	14,331	15,157	13,921
3	HEAVY DUTY TRUCKS & BUSES	14,550	14,732	17,604	19,605	29,633	33,060	35,448	35,396
4	MOTORCYCLES	1,515	844	1,087	963	977	1,709	1,151	1,172
5	NON ROAD VEHICLES	324	182	432	502	524	543	318	260
	TOTAL	60,576	60,769	64,520	69,719	83,279	91,457	96,502	102,880

Source: Road Transport Authority

2.11 Water Resources

Ethiopia is the “water tower” of Northeast Africa. There are 12 major river/drainage basins many of which are transboundary. The total annual runoff from these basins is estimated at about 111 billion cubic meters. The major rivers carry water and valuable soil and drain mainly to the arid regions of neighbouring countries. The total loss of top soil in Ethiopia has been estimated at 3 billion tons per year. The Wabi Shebelle and Genale drain to the desert areas of Somalia and flow into the Indian Ocean. Abay (Blue Nile), Tekeze-Angereb (Atbara) and Baro drain to the Sudan (and Egypt) and join the Mediterranean Sea through the Nile. The ground water and the gross Hydro-Electric potential in the country are estimated at 2.6 billion cubic metres and 139,250 Gigawatt hours (GWh) per year respectively. Based on available information the potential irrigable land in the country is about 3.7 million ha. There are also eleven major lakes with a total area of 750,000 ha. The biggest is Lake Tana found in the Northwestern part of the country while the rest of the lakes are found in the Rift Valley.

Although Ethiopia’s water resource is large, very little of it has been developed for agriculture, hydropower, industry, water supply and other purposes. To date only about 160, 000 ha (about 4%) of the potential irrigable land has been developed. National coverage of potable water supply stood at 26% by 1992 while coverage of sanitation services is only 7%, which is low by even the Sub-Sahran standards. There is also a wide divergence in the water supply coverage between urban (76%) and rural (18.8%) areas (MEDaC, 1999). If Ethiopia has to feed its fast growing population and improve the standard of living of its citizens this situation has to be changed. In this regard the government has recently formulated the Water Policy of the country. Basin wide integrated master plan studies which envisage development activities over the coming 30 to 50 years has also been undertaken for most of the major rivers.

2.12 Administration and Governance

Ethiopia is a Federal Democratic Republic. Member states of the Federation are the State of Tigray, the State of Afar, the State of Amhara, the State of Oromia, the State of Somalia, the State of Benshangul/Gumuz, the State of the Southern Nations, Nationalities and

Peoples, the State of the Gambela Peoples and the State of the Harari People. Addis Ababa and Dridawa are chartered cities.

Table 2.8: Major Drainage Basins and their Area, Annual Runoff, 75% Dependable Runoff, Ground Water, Gross Hydro-Electric and Irrigable Land Potential in Ethiopia.

No	River basin	Area in km^2	Available Water (annual runoff) $(x10^9m^3)$	Dependable (75%)	Irrigable Land (ha) (Medium & Large Scale)	Gross Hydroelectric potential Gwh/year	Ground Water potential $(x10^9m^3)$
1	Tekeze (Atbara)	86,500	8.2	-	189,500	4,231	0.2
2	Abay (Blue Nile)	204,000	52.62	51,480	1,001,550	78,820	1.8
3	Baro-Akobo	75,912	11.81	8.51	600,00	13,765	0.31
4	Omo-Gibe	79,000	17.96	14.46	86,520	22,454	0.1
5	Rift Valley	52,739	5.63	4.36	139,300	800	0.1
6	Mereb	5,900	-	-	67,560	-	0.05
7	Afar/Denakil	62,882	0.86	0.57	3,000	-	-
8	Awash	112,696	4.6	4.1	205,400	4,470	0.14
9	Aysha	2,223	0.22	0.15	-	-	
10	Ogaden	77,121	0.86	0.57	-	-	
11	Wabi-Shebelle	202,697	3.16	2.34	204,000	5,440	0.04
12	Genale-Dawa	171,042	5.88	4.58	423,300	9,270	0.03
	Total	1,132,712	111.8	51,520	2,320,130	139,250	2.77

Source: Ministry of Water Resources, Water and Development Bulletin, Volume 3, No. 9, 1998. Preliminary Water Development Master Plan for Ethiopia, 1990.

A policy of decentralisation of authority to regional administration has been pursued since 1991. The development strategy taken by the government is Agricultural Development Lead Industrialisation (ADLI) which is intended to be rural based and people focused. Cultural issues, peoples' rights to self determination and administration and individual entrepreneurship and equity are issues that are stressed under the current Constitution.

The regional/national governments have legislative, executive and judicial power over their administrative areas, except in matters of defence, foreign relations, citizenship, etc., which fall under the jurisdictions of the Federal Government. Promotion of social justice is another important aspect given due attention by Government. The rule of law is upheld with those committing crime and facing justice. Equity is a primary objective of the major policies of the government indicating clearly that priority is given to the rural areas, to the relatively less developed regions and to the low income sections of the people. Free press, the right to peaceful demonstration and the right to vote on issues that affect their lives are also important aspects of the current administration that promote popular participation.

The Federal Government administration is based on parliamentary system. Members of the two parliaments, the House of Representatives and House of Federation, are elected bodies from the people across all the regions and nationalities. The administration is being conducted in a transparent way in which the public is given access to discussion of parliamentary meetings and a chance to comment and raises issues.

Chapter 3

NATIONAL GREENHOUSE GAS (GHG) INVENTORY-1994

3.1 Introduction

One of the information that has to be contained in the National Communications of Parties to the UNFCCC is national inventory of greenhouse gases. Compilation of national greenhouse gas inventory is essential in the context of the UNFCCC. It allows each country to place its own emissions within the larger picture of global emissions. It provides a baseline against which each country's future emissions can be compared. It also provides a basis for the formulation of a national greenhouse gas mitigation policy. Compilation of the GHG inventory has the additional benefit of improving national statistics and in increasing awareness about climate change among stakeholders. It improves the study of the carbon cycle as well.

The objective of the GHG inventory was to identify the principal sources and to establish quantitative estimates of GHG emissions from different sectors in the country. The five emission sectors/ categories as prescribed by the IPCC 95 Guidelines for National Greenhouse Gas Inventories that are considered in this report are: Energy, Industrial Process, Agriculture, Landuse Change and Forestry and Waste. Emissions/removales of six gases are addressed from these sectors including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Nitrogen Oxides (NO_X)**,** Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOC) and Sulphur Dioxide (SO_2) for the years 1990-1995. In this report national greenhouse gas inventory for 1994, the Convention's base year for Non-Annex I party reporting , is presented in detail.

3.2 Methodology and Data Sources

Greenhouse gas emissions by sources and removals by sinks were calculated following the Revised 1996 IPCC Guidelines. The main inputs in the estimations of GHG emissions/removals are the activity data and emission factors. The activity data used in this inventory were collected from various sources including Ethiopian Rural Energy Development and Promotion Centre (EREDPC), Central Statistical Authority (CSA), Ethiopian Petroleum Enterprise (EPE), Food and Agricultural Organisation (FAO), Ministry of Agriculture (MoA), Addis Ababa Health Bureau, Addis Ababa Water and Sewerage Authority (AWSA), etc. An attempt has been made to include relevant historical activity data in the chapter of National Circumstances. As local emission factors are not yet developed, emission factors recommended by the IPCC were adopted in our GHG inventory with few exceptions.

The energy content of fuels used in this report is based on their lower (or net) heating values. For petroleum products, the heating values are based on data from the Ethiopian Petroleum Enterprise and in some cases standard data on petroleum heating values. The major determinant of the relative heating values is the specific gravity of the individual fuels. The petroleum product energy content values used in this report as they are usually used in the national energy balance are given in Table 3.1(Asress *et al.* 1999).

Table 3.1: Energy Content Values for Petroleum Products

PRODUCT	SPECIFIC GRAVITY (Kg/Lit)	(MJ/Lit)	LOWER HEATING VALUE (MJ/Kg)
Refinery gas	0.50	23.0	46.00
LPG	0.57	25.8	45.26
Gasoline	0.73	32.1	43.97
Jet-Kerosene	0.80	34.6	43.25
Other Kerosene	0.82	35.3	43.05
Diesel Oil	0.85	36.3	42.71
Fuel Oil	0.94	38.6	41.06
Lubricants	0.89	37.6	42.25
Bitumen	1.04	41.6	40.00
Crude Oil	0.86	36.6	42.56

Source: Ethiopian Petroleum Corporation

The heating value of biomass and biomass derived fuels which are widely used in the preparation of the energy balance of the country are given in Table 3.2.

Table 3.2: Heating Values of Biomass and Biomass derived Fuels

FUEL TYPE	HEATING VALUE (mj/kg)	IPCC DEFAULT VALUES
Wood	14.5	15
Dung	13.8	12
Crop residue	15.5	-
Bagasse	10.0	16.2
Sawmill Residue	14.5	-
Charcoal	29.0	30

Source: Ethiopian Energy Authority Data Base

Table 3.3: Carbon Emission Factors of Fuels Utilized in the Calculation are Default Values Adapted from IPCC

Fuel Type	Carbon Emission Factor (TC/TJ)
Refinery gas	18.2
LPG	17.2
Gasoline	18.9
Jet-kerosene	19.5
Other Kerosene	19.6
Diesel Oil	20.2
Fuel Oil	21.1
Lubricants	20.0
Crude Oil	20.0

3.3 Results and Discussion

3.3.1 Carbon Dioxide (CO_2)

Ethiopia's total (gross) CO_2 emission, excluding the Land-Use Change & Forestry (LUCF) sector, has been estimated at 2,596 Gg for 1994 (Tables 3.4 & 3.5). About 88% of this total CO_2 emission came from fossil fuel combustion in the Energy sector, and the Transport (road) sub-sector is the main emitter of CO_2 within this sector. The Industrial Processes sector contributed 12% of the total CO_2 emissions mainly as a result of cement production (Figure 3.1).

In 1994 biomass burned for energy, mainly in domestic households, emitted around 66,757 Gg of CO_2. This amount is not added to the total emissions as per the IPCC recommendation. IPCC's approch assumes that biomass resources are consumed on a sustainable basis. For example fuel wood burned one year but regrown the next only recycles carbon rather than creating a net increase in total atmospheric carbon. CO_2 emissions from International Bunkers are also not included in the total emissions.

The Land-Use Change & Forestry (LUCF) sector has been a net sink in 1994 which amounted to about -15,063 Gg of CO_2. This amount is a balance between Changes in Forest and Other Woody Biomass Stocks and Forest and Grassland Conversion sub-sectors. The country's stock of natural forests, woodlands, shrubs and plantations sequestered about -27,573 Gg of CO_2 in 1994 while emissions of CO_2 as a result of deforestation was estimated to be 12,510 Gg in the same year.

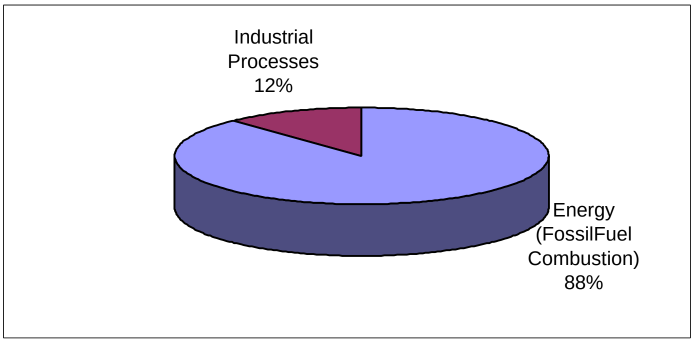


Figure 3.1: Sectoral Carbon Dioxide (CO_2) Emissions, excluding LUCF-1994

3.3.1.1 CO_2 Emissions from the Energy Sector

The total CO_2 emission from the Energy Sector is estimated at 2,287 Gg for 1994 (Asress *et al.* 1999). Figure 3.2 shows the sectoral share of CO_2 emissions from fossil fuel combustion for 1994. The Transport sub-sector is the largest consumer of the petroleum imported in to the country. CO_2 emission from the use of biomass as a fuel amounted to 66,757 Gg. This amount is not included in the national total on the basis of the assumption that biomass for energy is used sustainably (IPCC, 1996).

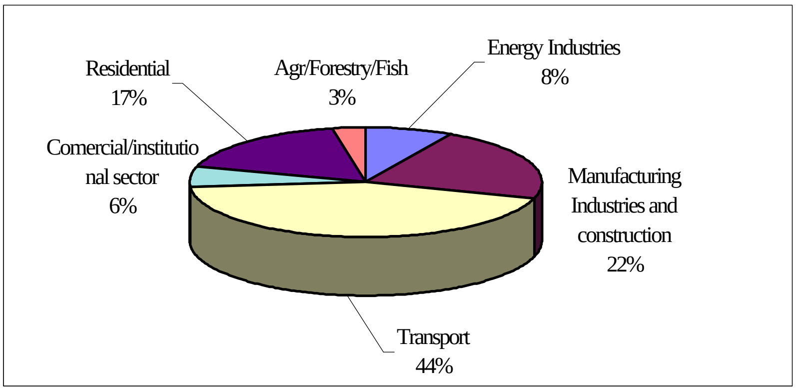


Figure 3.2: Sectoral Share of CO_2 Emissions from Fossil Fuel Consumption in 1994

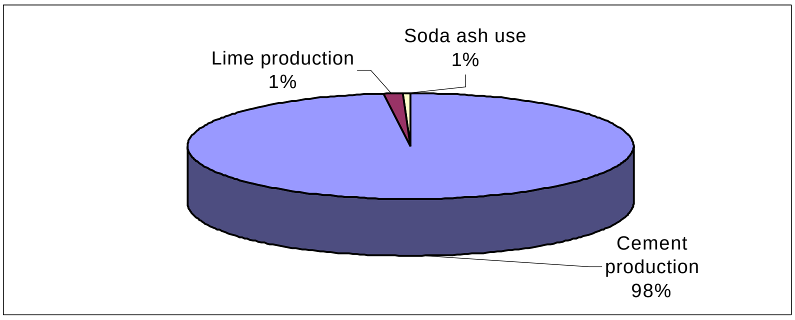


Figure 3.3: CO_2 Emissions from Industrial Processes Sector in 1994

3.3.1.2 CO_2 Emissions from the Industrial Processes Sector

The total CO_2 emission from the Industrial Processes Sector is estimated at 310 Gg for 1994 (Berhanu Kibret, 1999). The non-metallic Mineral Products sub-sector as a result of cement and lime production and soda ash use are identified as the sole source of CO_2 emission in this sector. The production of cement is the principal source of CO_2 emissions contributing 98% of the total for Industrial Processes Sector (Figure 3.3).

Table 3.4: Long Summary Report for National Greenhouse Gas Inventories (Gg) –1994

IPCC TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES 1994 (Gg)								
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals	**2,596**	**-15,063**	**1,808**	**24**	**165**	**7,619**	**396**	**13**
1 Energy	**2,287**	**0**	**194.0**	**2.8**	**83.8**	**3,368**	**394**	**13**
A Fuel Combustion (Sectoral Approach)	2,287		194.0	2.8	83.8	3,368	394	12.1
1 Energy Industries	182		1.0	0.1	3.4	33.6	1.7	1.9
2 Manufacturing Industries and Construction	496		0.7	0.1	4.4	61.4	1.2	5.6
3 Transport	1,001		0.1	0.0	10.1	49.5	4.9	4.3
4 Commercial/Institutional	143		6.8	0.1	2.5	113.2	13.1	0.0
5 Residential	391		1,84.9	2.5	62.4	3,109	3,67.5	0.0
6 Agriculture/Forestry/Fishing	69		0.0	0.0	1.1	0.9	0.2	0.1
B Fugitive Emissions from Fuels	0		0.0		0.04	0.06	0.44	0.7
1 Solid Fuels			0.0					
2 Oil and Natural Gas			0.0		0.04	0.06	0.44	0.7
2 Industrial Processes	**310**	**0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.3**	**0.2**
A Mineral Products	310					0.0	0.2	0.2
B Chemical Industry	0		0.0	0.0	0.0	0.0	0.0	0.0
C Metal Production	0		0.0	0.0	0.0	0.0	0.0	0.0
D Other Production	0				0.0	0.0	2.1	0.0
3 Solvent and Other Product Use				**0.0**			**0.0**	
4 Agriculture			**1,540.0**	**19.7**	**73.8**	**4,003.5**		
A Enteric Fermentation			1,337.0					
B Manure Management			49.5	0.0				
C Rice Cultivation			0.0					
D Agricultural Soils				17.7				
E Prescribed Burning of Savannas			148.4	1.8	66.4	3,894.6		
F Field Burning of Agricultural Residues			5.2	0.2	7.4	108.8		
5 Land-Use Change & Forestry		**-15,063**	**28.3**	**0.2**	**7.0**	**247.4**		
A Changes in Forest and Other Woody Biomass Stocks		-27,573						
B Forest and Grassland Conversion	12,510		28.3	0.2	7.0	247.4		
C Abandonment of Managed Lands								
D CO_2 Emissions and Removals from Soil	0							
6 Waste			**45.9**	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**
A Solid Waste Disposal on Land			28.2					
B Wastewater Handling			17.7	1.5				
C Waste Incineration								
Memo Items								
International Bunkers	**NE**							
Aviation	NE							

Marine	33							
CO_2 Emissions from Biomass	**66,757**							

Table 3.5: Short Summary Report for National Greenhouse Gas Inventories (Gg) -1994

IPCC TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES 1994 (Gg)									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total National Emissions and Removals		**2,595**	**-15,063**	**1,808**	**24**	**165**	**7,619**	**396**	**13**
1 Energy	Reference Approach(1)	**2,919**							
	Sectoral Approach(1)	**2,285**		**194**	**3.0**	**84**	**3,368**	**394**	**13**
A Fuel Combustion		2,285		194	3.0	84.0	3,368	3,94.0	12.1
B Fugitive Emissions from Fuels		0		0		0.04	0.06	0.44	0.7
2 Industrial Processes		**310**		**0**	**0.0**	**0.0**	**0**	**2.3**	**0.2**
3 Solvent and Other Product Use		**0**			**0.0**			**0.0**	
4 Agriculture				**1,540**	**19.7**	**73.8**	**4,003**		
5 Land-Use Change & Forestry		**(2) 0**	**(2) -15,063**	**28**	**0.2**	**7.0**	**247**		
6 Waste				**46**	**1.5**				
Memo Items:									
International Bunkers		**NE**							
Aviation		NE							
Marine		33							
CO_2 Emissions from Biomass		**66,757**							

(1) For verification purposes, countries are asked to report the results of their calculations using the Reference Approach and explain any differences with the Sectoral Approach. Do not include the results of both the Reference Approach and the Sectoral Approach in national totals.

(2) The formula does not provide a total estimate of both CO_2 emissions and CO_2 removals. It estimates "net" emissions of CO_2 and places a single number in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

3.3.1.3 CO_2 Emissions and Uptake in the Land-Use Change and Forestry (LUCF) Sector

Both emissions and uptake of CO_2 to or from the atmosphere can occur in the LUCF sector depending on the type of human activities. This sector can also be a source for the emissions of non-CO_2 trace gases.

According to FAO report some 14 million hectares or about 12.8% of the total land area of the country is estimated to be covered by forests (FAO, 1990). These forests are classified in to four categories namely Hill and Montane Forest, Dry Deciduous Forest, Very Dry Forest and Desert Formations.

The area of forest converted annually is used as a starting point for the calculation of CO_2 emission from biomass burning. Emissions from the burning of biomass can occur both on site and off site. The value of 0.5 for carbon fraction in the biomass and 0.9 for the combustion efficiency as proposed in the IPCC methodology were used.

The annual rate of forest clearing is not well documented in Ethiopia. Different sources of information were assessed and finally the FAO data set for forest resource assessment has been used to determine the average area cleared annually and converted to other forms of land use; such as: agriculture and grazing to calculate related emissions of greenhouse gases. FAO's estimate of annual deforestation ranges from 39,000 hectares in 1990 to 143, 000 hectares in 1995. The above ground biomass density of the different forest formations before and after clearing is adopted from related data for other African countries from the IPCC Guidelines.

The major contributor of forest clearing is agriculture particularly in the Hill and Montane forest areas of Bale, Illubabor, Wellega and Jimma areas. The rate of deforestation caused by the rapidly growing population and its need for agricultural cropland increases the areas of forests cleared every year. According to the Woody Biomass Inventory and Strategic Planning Project, the estimated annual rate of forests cleared for agriculture ranges from 112,660 ha in 1995 to 236,650 ha in 2015 (WBISPP, 1995). Much of the wood cleared is used for fuel and construction of houses with low on-site burning ratio.

The two sub-sectors that are considered in the estimation of CO_2 emission and removal are Forest and Other Woody Biomass Stocks and Forest and Grassland Conversion. CO_2 emissions and removals from Abandonment of Managed Lands and Soils have not been estimated due to lack of data and this makes the net LUCF contribution incomplete.

It can be seen from Table 3.6 that the main source of CO_2 emissions in the LUCF sector is the Forest and Grassland Conversion sub sector which includes emissions of CO_2 from on site and off site burning and decay of above ground biomass. It has been estimated that 12,510 Gg of CO_2 were emitted in 1994 as a result of Forest and Grassland Conversion i.e deforestation. On the other hand, natural and manmade forests of Ethiopia sequestered (removed) 27,573 Gg of CO_2 in the same year. That means there have been a net removal of 15,063 Gg of CO_2 in the sector in 1994.

Table 3.6: CO_2 Emissions and Uptake in the Land-Use Change and Forestry (LUCF) Sector in the period 1990-1995

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions (Gg)						change 1990/1995 (%)
	1990	1991	1992	1993	1994	1995	
Land-Use Change & Forestry	**-31,810**	**-25,504**	**-20,747**	**-19,391**	**-15,063**	**-10,653**	**-67**
A Changes in Forest and Other Woody Biomass Stocks	-36,536	-31,512	-28,397	-29,161	-27,573	-26,711	-27
B Forest and Grassland Conversion	4,726	6,008	7,650	9,769	12,510	16,058	240
C Abandonment of Managed Lands							
D CO_2 Emissions and Removals from Soil							

From Table 3.6, it can be seen that removal (uptake) of CO_2 by Ethiopian forests decreased by about 27% while CO_2 emissions increased by 240% in the period 1990-1995. The net CO_2 uptake by Ethiopian forests decreased by 67% in the same period. Despite the uncertainties, currently the LUCF sector is a significant sink of CO_2 in Ethiopia rather than a source of emissions to the atmosphere. However this sink capacity is decreasing rapidly.

3.3.2 Methane (CH_4)

The national methane emissions totaled 1808 Gg in 1994. The Agriculture sector (Enteric Fermentation) is by far the largest (84%) source of methane emissions in Ethiopia followed by the Energy sector resulting from fossil fuel use in the residential sub-sector (Figure 3.4). The Waste and the Land-Use Change & Forestry sectors make a small contribution to the total CH_4 emissions.

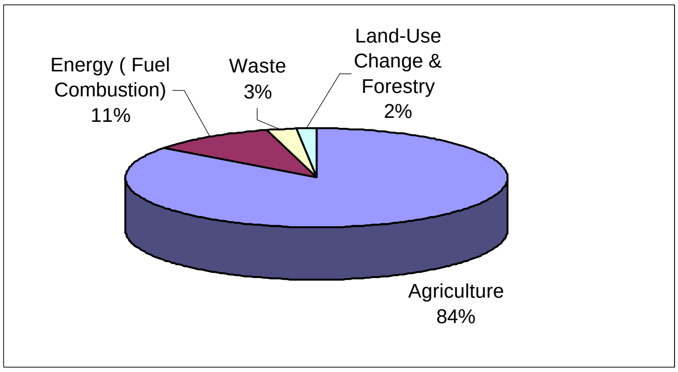


Figure 3.4: Sectoral Methane Emissions in 1994

3.3.2.1 CH_4 Emissions in the Agriculture sector

In 1994 a total of about 1540 Gg of methane was emitted from the Agriculture sector (Wondwosen *et al.* 2000). Out of this total amount about 87% or 1337 Gg was emitted from enteric fermentation. In the same year emissions of methane from prescribed burning of savannahs, manure management and field burning of agricultural residues are estimated to be 148 Gg, 49 Gg and 5 Gg respectively. Rice cultivation is not practised in Ethiopia.

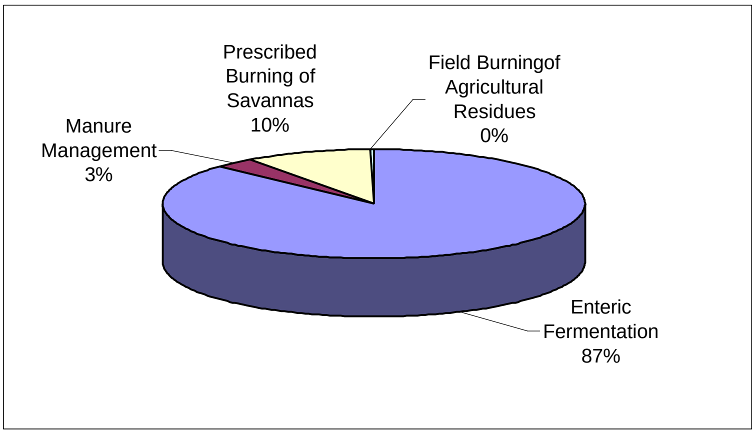


Figure 3.5: CH_4 Emissions in the Agriculture sector in 1994

3.3.2.2 CH_4 Emissions in the Energy sector

In 1994 a total of about 194 Gg of methane was emitted from the Energy sector. The Residential and Commercial/Institutional sub-sectors contributed 95% and 4% to these methane emissions respectively. The remaining small amount is contributed by the Energy Industries, Manufacturing Industries and Construction and the Transport sub sectors (Table 3.5).

3.3.2.3 CH_4 Emissions from Waste sector

Solid waste disposal on land from Addis Ababa City and other urban centres and Wastewater handling (domestic + industrial) are the main sources of methane in the Waste sector. Incineration of waste is not practised in Ethiopia.

Domestic wastewater sources are residences, public toilets, commercial centres (hotels, restaurants, etc.), hospitals, and institutions (governmental, non-governmental & private). Sources for Industrial Wastewater are factories of beverage, tanneries (leather & foot wears), textiles, food, pulp & paper, petrochemicals (dying, plastics & related), soap & detergents, iron & steel, non-ferrous metals, rubber, tobacco, pharmaceuticals and wood processing.

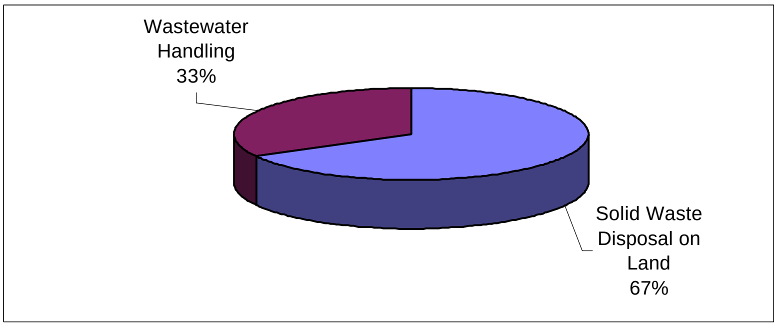


Figure 3.6: Percentage Contributions of Methane Emissions from Solid Waste Disposal on Land from Addis Ababa City and Other Urban Centers and Wastewater Handling in 1994.

It is estimated that about 46 Gg of Methane was emitted from the Waste sector in 1994. Solid Waste Disposal on land from Addis Ababa city and other urban centers and Wastewater Handling (domestic + industrial) contributed about 28 and 18 Gg to the Methane emitted respectively (Fikru Tesema, 1999 and Adnew Adam, 1999). Almost all of the Methane emitted in Wastewater Handling comes from Domestic Wastewater. Methane emission from Industrial Wastewater is practically negligible (Adnew Adam, 1999).

3.3.2.4 CH_4 Emissions from Land-Use Change & Forestry sector

In 1994 methane emissions from the Land-Use Change & Forestry sector were estimated to be 28 Gg and this amount was released solely from the Forest and Grassland Conversion sub sector.

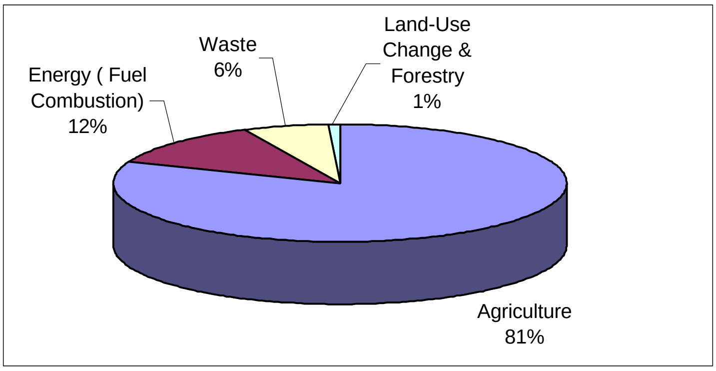
3.3.3 Nitrous Oxide (N_2O)

The national total Nitrous Oxide emissions has been estimated to be about 24 Gg in 1994. The Agriculture sector is the principal source of Nitrous Oxide in Ethiopia contributing about 81% of the total emission mainly as a result of fertiliser use in agricultural soils. The Energy and Waste sectors contribute 12% and 6% respectively to the total national Nitrous Oxide emissions. The contribution of the Land-Use Change & Forestry sector to the N_2O emissions is found to be negligible (Figure 3.7).

3.3.3.1 N_2O Emissions in the Agriculture Sector

There are three sources of Nitrous Oxide in the Agriculture sector; namely: Agricultural Soils, Prescribed Burning of Savannas and Field Burning of Agricultural Residues, in order of importance (Figure 3.8). Nitrous Oxide emission in this sector has been estimated to be 20 Gg for 1994.

Figure 3.7: Sectoral Emissions of N_2O in 1994.



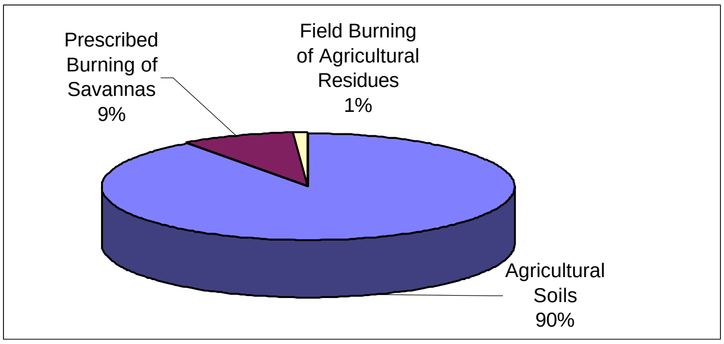


Figure 3.8: Percentage Share of N_2O Emissions in the Agriculture Sector in 1994

3.3.4 Carbon Monoxide (CO)

In 1994 Carbon Monoxide (CO) emissions in Ethiopia have been about 7619 Gg and most of these emissions came mainly from the Agriculture (53%) and Energy (44%) sectors. The Land-Use Change & Forestry sector contributed about 3% to the total CO emissions (Table 3.5 and Figure 3.9).

Carbon Monoxide in the Agriculture sector is emitted mainly as a result of Prescribed Burning of Savannas (3895 Gg) followed by the Field Burning of Agricultural Residues sub sectors (109 Gg). Wood fuel combustion in the Residential sub-sector is the main source of CO (3109Gg) in the Energy sector. Forest and Grassland Conversion is the sole source of CO (247 Gg) in the Land-Use Change & Forestry sector.

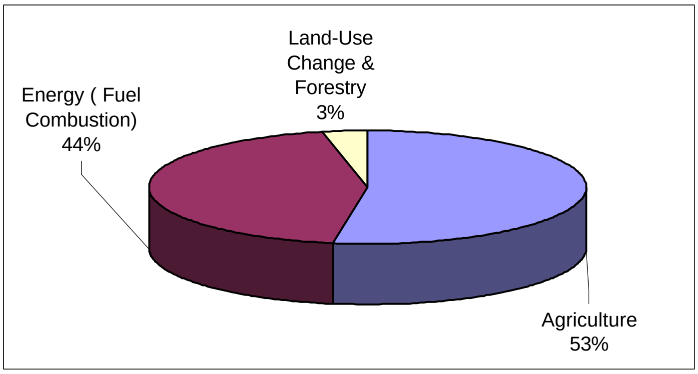


Figure 3.9: Sectoral Contributions to Carbon Monoxide (CO) Emissions in Ethiopia in 1994

3.3.5 Nitrogen Oxides (NO_X)

For 1994, the total Nitrogen Oxide emissions of Ethiopia is estimated at 165 Gg. The three sectors that contribute to NO_X emissions are Energy (51%), Agriculture (45%) and LUCF (4%). Fuel wood use in households and Prescribed Burning of Savannas are the main sources of NO_X in the Energy and Agriculture sectors respectively.

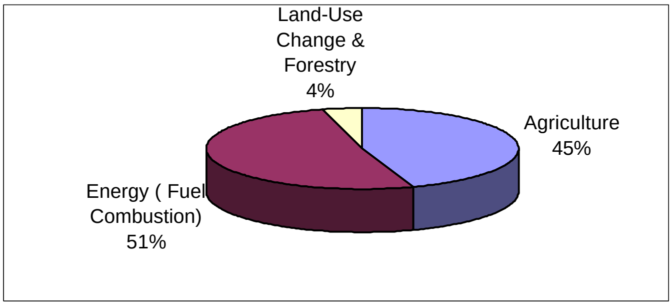


Figure 3.10: Sectoral Contributions to Nitrogen Oxide emissions in Ethiopia in 1994

3.3.6 Non-Methane Volatile Organic Compounds (NMVOC)

The total NMVOC emissions in Ethiopia have been estimated at 396 Gg for 1994. The Energy sector is the major source of NMVOCs originating mainly from the residential sub-sector. The productions of sugar, bread and alcohol in the Food and Drink sub-sector as well as Road Paving & Glass Production in the Mineral Products sub-sector of the Industrial Processes sector produce a very small amount of NMVOCs.

3.3.7 Sulphur Dioxide(SO_2)

The amount of Sulfur Dioxide emitted in Ethiopia has been about 13 Gg in 1994, originating mainly from the Energy sector. Fossil fuel use in the Manufacturing Industries/ Construction and Transport sub sectors are the main sources of SO_2 in the Energy sector. The Industrial Processes sector emits a very small amount of SO_2 as a result of cement production. An emission factor of 0.3kg SO_2 /tone of cement production is assumed in the calculation of Sulfur Dioxide emissions.

3.4 Aggregated Emissions and Trends

GHGs vary in their effectiveness to trap heat in the atmosphere. The concept of Global Warming Potential (GWP), which indicates the relative effectiveness of various greenhouse gases in contributing to global warming, is applied for comparison purposes.

Results of aggregating all sectors excluding CO_2 emissions/removals from the LUCF sector over the three GHGs in terms of CO_2 equivalents using the IPCC 1995 GWP factors in a hundred yeas time horizon for the year 1994 are given in Table 3.7 and Figures 3.11 & 3.12.

GHG emissions in Ethiopia totalled about 48,003 Gg CO_2 -equivalents in 1994, excluding CO_2 emissions/removals in the LUCF sector. With the population of 53.5 million for the same year, per capita emission would be 0.8976 tonnes of CO_2-equivalents per year. Sectorwise Ethiopia's GHG emissions profile is dominated by emissions from Agriculture contributing 80% of the total while gaswise it is dominated by CH_4 contributing 80% of the total CO_2 equivalent emissions in 1994.

There is a general increasing trend of GHG emissions in Ethiopia in the period 1990-1995 (Figures 3.13 & 3.14). The relative comparison of GHG emissions for the years 1990 and 1995 shows that total (gross) CO_2 emissions (i.e. emissions from the Energy and Industrial Process sectors) have increased by about 24% while emissions of CH_4 and NO_X increased by 1% and 119% respectively (Table 3.8). It can be noted from Table 3.8 that the rate of growth in GHG emissions vary across sectors and sub sectors. The sink capacity of Ethiopia in the LUCF sector is also decreasing rapidly. Aggregate emissions of GHGs in terms of CO_2–equivalents has increased by 12% (Table 3.9).

3.5 Uncertainty Assessment

The quality of the activity data and emission factors used in the national inventory of greenhouse gases determines the reliability of the estimates. In this regard high confidence can be put in the estimates of CO_2 emissions from the Energy and Industrial Process sectors. Estimates of CO_2 emissions/removals from the LUCF sector is highly uncertain. A medium confidence can be put on emissions of CH_4 from Agriculture, Waste and Energy sectors. Estimates of N_2O including NO_X, CO, NMVOC and SO_2 could be highly uncertain. In order to reduce the uncertainties in the GHG inventory there is a need to improve the collection and quality of the national data and to develop local emission factors.

Table 3.7: 1994 Emissions and Removals in Absolute Values (Gg) and Aggregated Emissions in terms of CO2- equivalent Emissions (Gg) using the 1995 IPCC GWP Factors over a 100 years time horizon.

	Emissions and Removals in absolute values (Gg)				**CO_2-equivalent Emissions (Gg)**				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	CO_2	CH_4	N_2O	Aggregated	%
Energy (Fuel Combustion)	**2,285**		**194**	**3.0**	2,285	4074	930	7,289	**15**
Industrial Processes	**310**		**0**	**0.0**	310	0	0	310	**1**
Agriculture			**1,540**	**19.7**		32340	6116	38,455	**80**
Land-Use Change & Forestry		**-15,063***	**28**	**0.2**		594	60	654	**1**
Waste			**46**	**1.5**		963	454	1,418	**3**
Total National Emissions and Removals	**2,595**	**-15,063***	**1,808**	**24**	2,595**	37968	7440	48,003	**100**
%					**5**	**79**	**15**	**100**	

*** It represents "net" emissions of CO2 in the LUCF sector. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).**

**** carbon emissions/ sinks from the LUCF sector are not included in total CO_2 emissions**

Table 3.9: Greenhouse Gases Emissions for the Period 1990-1995 in terms of CO_2-equivalent (Gg).

	1990	1991	1992	1993	1994	1995	% change 1990/1995
Carbon Dioxide (CO2)	2,308	1,879	2,073	2,402	2,595	2,862	**24**
Methane (CH4)	37800	38661	37320	37498	37968	38235	**1**
Nitrous Oxide (N2O)	3430	4579	4705	4818	7440	7498	**119**
Total	**43537**	**45119**	**44098**	**44718**	**48003**	**48595**	**12**

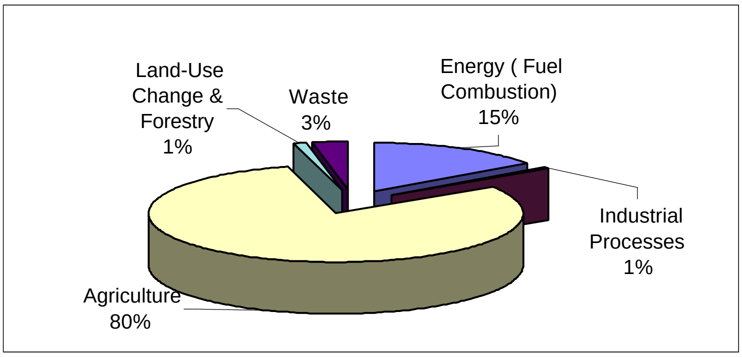


Figure 3.11: Percentage Contribution by Sector to the Total (Aggregated) GHG Emissions in CO_2 equivalent in 1994

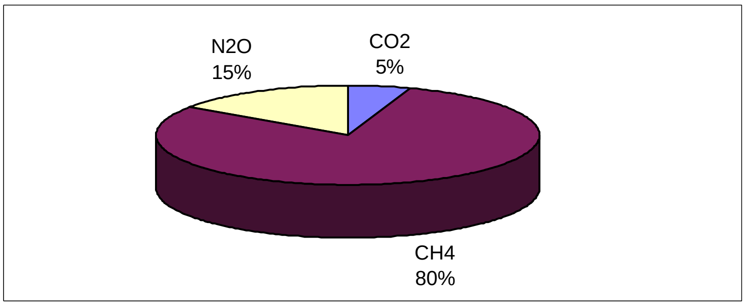


Figure 3.12: Percentage Contribution by Gas to the Total (Aggregated) GHG Emissions in terms of CO_2 equivalents in 1994

Table 3.8: Greenhouse and Other Gases Emissions for the Period 1990-1995 in Absolute Values (Gg)

No		1990	1991	1992	1993	1994	1995	% change 1990/1995
	Total Carbon Dioxide (CO2) Emissions without LUCF (1+2)	**2,308**	**1,879**	**2,073**	**2,402**	**2,595**	**2,862**	**24**
1	Energy (Fossil Fuel Combustion)	2,168	1,756	1,880	2,166	2,285	2,519	16
2	Industrial Processes	139	123	193	235	310	343	146
3	Land-Use Change & Forestry (LUCF)	-31,810	-25,504	-20,747	-19,391	-15,063	-10,653	-67
4	Emissions from Biomass Use (not included in total CO2 emissions)	49,749	49,486	50,068	54,451	66,757	55,961	12
5	International Bunkers (not included in total CO2 emissions)	NE	98	67	33	NE	NE	NE
	Methane (CH4)	**1,800**	**1,841**	**1,777**	**1,786**	**1,808**	**1,821**	**1**
6	Agriculture	1,581	1,612	1,535	1,530	1,540	1,538	-3
7	Energy (Fuel Combustion)	166	173	181	189	194	196	18
8	Waste	44	43	44	45	46	49	13
9	Land-Use Change & Forestry	10	13	17	22	28	37	272
	Nitrous Oxide (N2O)	**11**	**15**	**15**	**16**	**24**	**24**	**119**
10	Agriculture	7	11	11	11	19.7	20	189
11	Energy (Fuel Combustion)	2	2	3	3	3.0	3	25
12	Waste	1	1	1	1	1.5	1	11
13	Land-Use Change & Forestry	1	0	0	0	0.2	0	-63
	Nitrogen Oxides (NOX)	**160**	**155**	**158**	**171**	**165**	**166**	**3**
14	Agriculture	82	78	76	80	73.8	71	-13
15	Energy (Fuel Combustion)	76	73	77	86	84	86	13
16	Land-Use Change & Forestry	2	3	4	5	7.0	9	272
	Carbon Monoxide (CO)	**7,884**	**7,518**	**7,553**	**7,560**	**7,619**	**7,576**	**-4**
17	Agriculture	4,573	4,399	4,251	4,104	4,003	3,867	-15
18	Energy (Fuel Combustion)	3,224	3,006	3,155	3,265	3,368	3,387	5
19	Land-Use Change & Forestry	86	113	146	190	247	322	272
	NMVOC	**313**	**353**	**371**	**389**	**396**	**403**	**29**
20	Energy (Fuel Combustion)	310	350	368	387	394	**401**	29
21	Industrial Processes	3	3	2.3	2	2.3	3	-3
	Sulfur Dioxide(SO2)	**11**	**9**	**9**	**11**	**13**	**13**	**16**
22	Energy (Fuel Combustion + Fugitive)	11	9	9	11	13	13	15
23	Industrial Processes	0.1	0.1	0.1	0.1	0.2	0.2	149

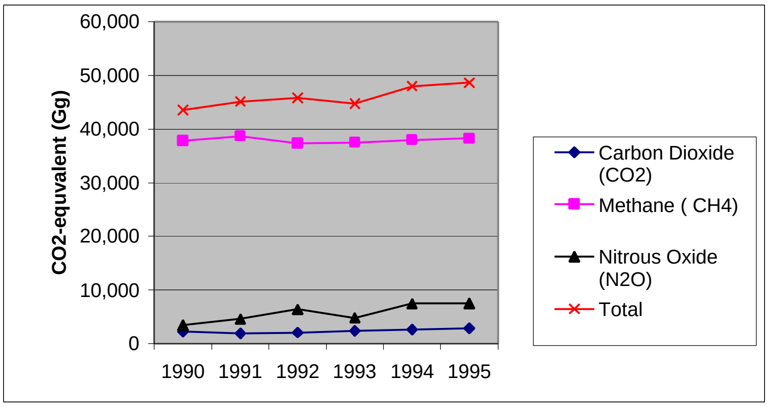


Figure 3.13: Trends in CO2, CH4 and N2O Emissions (Gg) Expressed in terms of CO_2 equivalents.

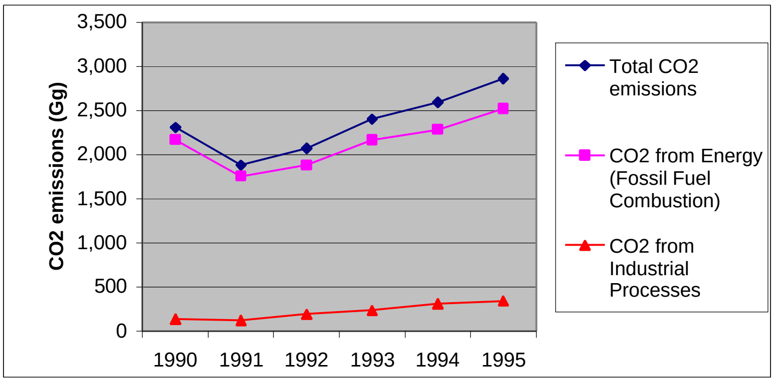


Figure 3.14: Trends in CO_2 Emissions (Gg) from the Energy and Industrial Process Sectors.

Chapter 4

ASSESSMENT OF GREENHOUSE GAS MITIGATION OPTIONS

4.1 Introduction

Attaining the ultimate objective of the UNFCCC requires the participation of all Parties in reducing GHG emissions and enhancing sinks. It has been noted in Chapter 3 that there is a general increasing trend of GHG emissions in Ethiopia in the period of 1990-1995 and it is expected to increase in the future along with socio-economic development and population growth. The sink capacity of the country in the LUCF sector is also decreasing rapidly due to deforestation and other activities.

It is clear that the contribution of Ethiopia to the global emission of GHGs is negligible. While the alleviation of poverty and socio-economic development is Ethiopia's priority, the country is also concerned with the protection of local and global environment. As indicated in the 1994 Environmental Policy, Ethiopia is committed to work with the international community to fight antropogenic climate change.

The country needs to identify and implement options which could have the twin objectives of sustainable economic development and GHG mitigation with the financial and technical support and appropriate technology transfer from developed countries. In this chapter effort has been made to identify such options in the Energy, Land Use Change and Forestry, Agriculture and Waste sectors. It should be noted that mitigation options identified in each sector are a result of preliminary analysis and further study is recommended.

4.2 Energy Sector

As stated in section 2.9, the energy supply and consumption pattern in Ethiopia is characterized by heavy reliance on biomass fuels. Supply and hence consumption of commercial fuels such as liquid petroleum and electricity (mainly hydro) is, in relative terms, marginal. With very little fossil fuel resources and limited foreign currency availability, Ethiopia will continue to depend heavily on biomass fuels.

The dependence of the majority of households on biomass resources (wood fuels, crop residues and dung) has been demonstrated to have adverse effects on the ecology of the country. Where such fuel are not sustainably produced they have also contributed to increasing the overall GHG emissions.

The total energy consumption of the country in 1994 was estimated at 698.84 TJ of which biomass contributed 95.1% (Dereje *et al.* 2000). Liquid petroleum fuel and electricity contributions were at about 4.3 and 0.6 % respectively. Sectoral consumption of energy was dominated by the household sector accounting for 89.6 % of the total. The second most important sector in terms of energy consumption was industry (4.5%) followed by services and others (3.6%) while agriculture and transport were attributed to the remaining 2.3%.

In this section results of analysis of energy demand and greenhouse gases emission as well as mitigation measures proposed for reduction of CO_2 emissions from the energy sector are presented.

The analysis was done using the Long-range Energy Alternative Planning Model (LEAP). Energy demand for each sector was computed using the 1994 baseline energy consumption values and intensities for each energy sector. Macro economic variables were used for projection of energy demand. The household sector demand for energy was assumed to be driven by population size and all other economic sectors by their respective rate of growth of GDP.

Using 1994 as a base year, sectoral energy consumption and GHG emissions generation for the year 2010 and 2030 were computed for a base line case (business as usual) and by considering most likely and possibly low cost intervention for the reduction of fuel consumption and GHG emissions (Mitigation scenario).

Two major GHG mitigation scenarios were considered. These include intervention measures of demand side management in the household sector (introduction of improved stove) and, on the supply side management introduction of improved charcoal kilns and substitution of Photo Voltaic (PV) lanterns for kerosene lighting. Use of gasohol (ethanol substitution for gasoline) was considered in the road transport sub-sector.

The results of the analysis show that, without any intervention measures, total energy consumption would rise by a factor of 1.7 in 2010 and 3.2 by 2030 as compared to the base year values. In the household sector both demand management and supply side options were considered. On the demand side, management options such as saving of energy through large scale introduction of improved cooking and baking stoves were considered. The coverage includes fuelwood and charcoal saving in both urban and rural areas. Introduction of improved wood stoves was considered to be effected in 50% of the rural household both by 2010 and 2030.

In urban areas the penetration rate of improved wood stoves was assumed to be 50%. Similarly, for the year 2010, for charcoal stoves the penetration rate in rural and urban areas was considered to be 25 and 60% respectively, and for 2030 the corresponding penetration rates were 50% and 75%.

On the supply side improved kilns with efficiency of 34% were introduced with the aim of reducing overall wood demand for charcoal making if otherwise converted using traditional kilns (efficiency of about 12-15%, mass basis). Assumption is made that by the year 2010 and 2030, respectively, 25 and 50% of the total charcoal demand is to be met with charcoal produced using improved kilns. In rural areas ten percent of the rural households are assumed to replace their kerosene lanterns lighting devices with a 7W PV lantern units.

Mitigation scenario considered in the transport sector is specifically targeted to reduction of gasoline consumption in the road transport sub-sector. The choice of this scenario was based on current government interest in blending ethanol with Gasoline. The mitigation scenario assumes that by the year 2010, 29.5 thousand m^3 of ethanol (for blending purposes) could be made available from the existing four sugar companies: Wonji-Shoa, Wongi-Gefersa, Methhara and Fincha Sugar Factories.

The mitigation options considered would result in total reduction of demand for fuel wood and charcoal by about 17.6 % in 2010 and 14.2 % by 2030, compared to the base case values of the respective years, if they are fully implemented. The respective GHG emission reductions attained through the mitigation measures adopted would be a reduction of 10.5 % and 8.3% of total CO_2 by 2010 and 2030 respectively (Dereje *et al.* 2000).

The CO_2 emission reduction costs both in the household and road transport sectors were computed as USD per CO_2 equivalent using 20 years Global Warming Potential (GWP) coefficients. Carbondioxide reduction cost using PV lighting to displace kerosene lanterns were found to be excessively high and it is not included in discussion here.

The computations are made based on emission coefficients reported in the LEAP model and considerations of marginal costs of introducing improved stoves in the household sector and marginal fuel costs in the transport sector.

In urban households, the CO_2 reduction cost associated with introduction of improved fuel wood and charcoal stoves was 2.2 and 3.6 USD per ton of CO_2 respectively. On the other hand in rural areas the CO_2 reduction cost for wood and charcoal improved stoves is about 0.57 and 31.1 USD per ton of CO_2 respectively. However, these costs were computed assuming that all biomass supply was on unsustainable basis. The emission reduction costs would therefore be higher when part of the biomass is considered to be supplied sustainably (Dereje *et al.* 2000).

In the road transport sector the CO_2 reduction cost resulting from use of Gashol (E-10) would be about minus 1.9 US$ per ton of CO_2. This result indicates a win win situation. The negative CO_2 reduction cost resulted from higher Gasoline cost as compared to Ethanol as well as higher CO_2 emission per unit mass from Gasoline than Ethanol (Dereje *et al.* 2000).

This study relied mainly on secondary data available from governmental and other non-governmental institutions. It should also be acknowledged that the mitigation scenarios developed and applied are few and limited to the household and road transport sub-sector due to limited availability of information on technological option as well as costs of technologies. Further analysis needs to be done on more refined data and by considering other mitigation options.

4.3 Land-Use Change and Forestry (LUCF) Sector

Many studies have shown that measures in the LUCF sector could play a key role in combating climate change. Forestry and Land-Use based interventions that have the potential to significantly contribute to climate change mitigation are categorized as follows.

- Protection of existing carbon reservoirs from losses associated with deforestation, forest and land degradation and other land management practices.
- Enhancing carbon sequestration and expanding carbon stores in forests soils through reforestation, afforestation and forest management practices.
- Reducing emissions of other greenhouse gases such as Methane and Nitrous Oxide from land use and agricultural interventions ranging from fire management to more efficient use of nitrogen based fertilizers.
- Using biomass as a substitute for fossil fuels through the production of woody biomass.

The mitigation options that are considered for assessment in the LUCF sector are forest protection and afforestation. The model used for the analysis is the Comprehensive Mitigation Analysis Program (COMAP). The outputs from COMAP are the annual and total incremental carbon conserved and the cost effectiveness of the mitigation efforts made. The area selected for analyzing the mitigation option is Belete Gera forest located in the southwestern part of Ethiopia, in the Oromiya Region. The area to be brought under protection and natural regeneration is estimated at 17,000 hectares over 30 years planning period. The results obtained indicate that there would be an increase of carbon pool in the year 2030 with the intervention scenario and a decrease of carbon pool with non-intervention scenario (Million Bekele, 2000).

In the second mitigation option (afforestation), planting of 21,000 hectares was envisaged and the expected result is an increase in carbon pool compared to the baseline scenario.

4.4 Agriculture Sector

Ethiopia is endowed with huge livestock resource. The livestock population is second to nil in the continent and tenth in the world. Output of livestock commodities i.e. meat, milk, eggs, wool, hides and skins accounted for 30% of agricultural domestic product. These calculations are based upon both marketed and subsistence production. If non-monetized contributions (traction and manure) were included, the livestock contribution to agricultural domestic product would be increased by 50% (Wondwosen *et al.* 2000). The livestock resource of the country is characterized by low productivity levels.

Population increase, urbanization and income change will profoundly alter the prospects for sustained economic development. The driving force for change will be the increasing human population. The population is currently increasing by 3.1%. Population growth will be accompanied by a dramatic migration of people from rural to urban areas, which will create new patterns of food production, marketing and consumption. If agricultural production grows no faster than it did in the past the country will face massive deficits in supplies of agricultural production.

Clearly, strategies must be formulated that will increase food production to feed the rapidly growing population of Ethiopia in a sustainable manner. Strategies that will enhance economic development of the country, increase incomes, promote the welfare of rural people and protect the environment needs to be formulated and implemented.

4.4.1 Enteric Fermentation

Animal husbandry results in methane emissions from two main sources: enteric fermentation (the digestive processes of animals); and manure management system facilities. Enteric fermentation emissions are driven principally by the quality and quantity of feed consumed by ruminant animals. Non-ruminant livestock produce a relatively small amount of methane from enteric fermentation. The total amount of Ethiopian methane emission from enteric fermentation in 1994 was about 1337 Gg. It should be noted that enteric fermentation is by far the largest source of methane in the country.

Mixed Crop/Livestock Farming

Increased population pressures on limited land will lead to intensification of agriculture. Growing competition between crop and livestock farming systems is the most efficient and sustainable means of increasing food production. Key elements in the contribution of livestock to intensification are traction, manure and enhanced income per unit of land. Crops and livestock can no longer be viewed as separate and inevitably competitive enterprises, rather mixed farming system optimize resource use and in addition it will reduce carbon dioxide and methane generation in agricultural systems.

Mixed farming will maximize the degree of self-reliance of the system, since a variety of products will be obtained with minimum inputs to maintain soil fertility. The integration of livestock into agricultural systems based on food crops calls for efficient use of crop residues and agro-industerial by-products by the ruminants.

Improved nutrition through strategic supplementation and other methods

Methods for increasing production from roughage diets include supplementation to ensure an active and efficient fermentative digestion and supplementation to increase the efficiency of nutrient utilization of the basal forage. Urea increases the efficiency of fermentative digestion in the rumen stimulating digestibility and feed intake. Supplementation with a protein meal that largely by passes rumen fermentation provides a better balance of nutrients to the animal and increases live-weight gain and efficiency of feed utilization.

Treatment of forages to improve digestibility

A variety of physical and chemical treatments can be used to increase the potential rate and extent of digestibility of fibrous feeds.

Improved production through improved genetic characteristics

The livestock species in Ethiopia are indigenous types characterized by low production. However, they are well adapted to the environment and have resistance to a number of endemic diseases. Little activity has been done to improve the productivity of local stocks through selection and breeding. Continued improvements in genetic potential through cross breeding and selection indigenous stock will increase productivity and thereby reduce methane emission per unit product. Production efficiency can further be improved through proper veterinary care, sanitation, ventilation, nutrition and animal comfort.

4.4.2 Manure Management

Manure related emissions result from the anaerobic decay of organic material in livestock manure. Manure management systems that promote anaerobic conditions such us liquid/slurry storage facilities and anaerobic lagoons produce the most methane. Methane emissions from such sources can be recovered and used as energy source. Methane recovery technologies have been successfully used and demonstrated under a variety of conditions, and have been shown to reduce methane emissions by up to 70 or 80% (USEPA, 1993b.). This emission reduction option will be effective or feasible for large or small to medium confined or semi-confined farm operations. A relatively small percentage of livestock manure is managed in this manner in country and emission of methane from these systems is negligible. Manure spreading directly on soils, crops and pastureland and composing maintain aerobic conditions and have limited methane production potential. Since manure spreading on soils, crops and pastureland is the most common practice in extensive systems of Ethiopia, it should be further encouraged and maintained. Using dung as a fuel release methane because of combustion. The 1994 estimates of methane emissions from livestock manure in Ethiopia was about 49.5 Gg.

4.4.3 Fertiliser Application

Factors that affect N_2O emissions from fertilizer application are little understood. However, mitigation options such as adjusting the rate of Nitrogen fertilizer application, placing N fertilizer deeper in the soil and appropriate timing of fertilizer application to match the needs of the crop could help to reduce N_2O emissions.

4.4.4 Soil Carbon in Cultivated Soils

While there are uncertainties in the estimates of carbon dioxide emissions from cultivated soils, the use of conservation tillage techniques have shown to be effective in reducing soil organic carbon (SOC) loss and, in some cases, leading to SOC accumulation.

Effects of long-term cultivation and grazing on soil carbon storage and plant biomass:

A simulation approach to two case studies from Ethiopia have used an ecosystem modeling technique (CENTURY model) to evaluate the impacts of land use on fluxes of carbon. The model was parameterized for different situations for the Ethiopian case study.

The Ethiopian rangeland ecosystems appear to be sensitive to changes in land management that affect the total system carbon (C) storage. Manipulations of inputs and outputs of these systems can be used to enhance the C storage of degraded lands. Manure return is the best management scheme that promotes increased plant production and soil carbon storage at the highland site of Sheno followed by traditional management practices. All options that included low grazing intensity had lower plant production than manure return, the traditional, or the current management practices. The most important management practice in the Borena pastoral system is rehabilitation of overgrazed watering points and long-term settlement areas and redistribution of manure that is accumulated near these settlements. In sites with 50 years of simulated manure return, soil carbon was increased from 450 g C/m^{2}over 500 g C/m^2. These management practices are able to stabilize C stocks and permit long-term utilization of these important pastoral resources in Ethiopia (Ojima. D, etal, 1996).

4.5 Waste Sector

Methane emissions originate from several anthropogenic sources including: municipal solid waste landfills and open dumps, wastewater treatment, domesticated livestock and coal mining. Methane emission of the Addis Ababa City landfills accounts for 18% of the total emissions of urban centers of Ethiopia, 20% of the total emissions of waste sector and 2% of the total country emission.

The Addis Ababa City landfill could be the focus of mitigating methane emissions. Two different scenarios are basically defined in the methane mitigation analysis. One scenario reflects a baseline case and the other reflects the impact of mitigation options. Options like composting, incineration and landfill gas recovery are the options that have potentials to mitigate methane emissions from SW of Addis Ababa City.

Selection and adoption of an option for mitigation depend upon cost of technology, cost of labor and energy and socio-cultural attitudes of the community. Preliminary analysis shows that cost of methane mitigation by composting is the cheapest while landfill methane recovery is the second cheapest (Fikru Tessema, 2000).

Composting is the most promising measure and more reliable solid waste treatment option for Addis Ababa City because 68% by weight of the solid waste is organic. Compost from such type of wastes can be a good quality, consistently produced, and accepted by customers and meeting needs of end users.

Table 4.1: Analysis of Mitigation of Methane Emission from Solid Waste of Addis Ababa City

Mitigation	Methane Emissions from Solid Waste				
Scenario	Baseline and Mitigation Scenario				
Country	Ethiopia				
Year	1994 – 2030				
	1994	2000	2010	2020	2030
BASELINE SCENARIO: • Emissions (in Gg)	4.65	9.52	12.73	16.24	19.45
MITIGATION SCENARIO: • Reduction by Composting (30% of yearly emission, in Gg)	0.00	2.86	3.82	4.87	5.84
• Reduction by Incineration (45% of yearly emission, in Gg)	0.00	4.28	5.73	7.31	8.75
• Reduction by gas recovery from SLF (70% of yearly emission, in Gg)	0.00	6.66	8.91	11.37	13.62

Establishing and operating incineration plants is not only for GHG emission reduction but it can assist the solid waste management service in the improvement of collection and transport of wastes by increasing the number of disposal sites and increasing frequency of collection.

Sanitary landfill is an essential tool for mitigating GHG and disposing safely all types of solid wastes. It is the only option for the disposal of the unwanted end product of other different solid waste treatment options.

This methane emission mitigation analysis, therefore, recommends composting and landfill gas recovery since they are less costly for mitigating Addis Ababa landfill methane emissions. Incineration**,** even if its cost is not attractive, its impact on methane emissions from solid waste is significant.

Chapter 5

CLIMATE CHANGE IMPACT/VULNERABILITY ASSESSMENTS AND ADAPTATION OPTIONS

5.1 Introduction

Climate change is expected to have adverse impacts on socio economic development of all nations. But the degree of the impact will vary across nations. The IPCC findings indicate that developing countries will be more vulnerable to climate change. Preparing for adaptation to the impacts of climate change by carrying out climate change impact assessments is one of the commitments of Parties under Article 4.1 of the UNFCCC.

Climate Change may have far reaching implications to Ethiopia for various reasons. Its economy mainly depends on agriculture, which is very sensitive to climate variations. A large part of the country is arid and semiarid and is highly prone to desertification and drought. It has also a fragile highland ecosystem, which is currently under stress due to population pressure. Forest, water and biodiversity resources of the country are also climate sensitive. Vector-born diseases, such as malaria also affect Ethiopia, which are closely associated with climate variations. Climate change is therefore a case for concern.

It is critical that Ethiopia should carefully consider and prepare for possible impacts of climate change. The country has experienced environmental problems such as recurring droughts, a high rate of deforestation, soil degradation and loss, over grazing, etc., which may be exacerbated by climate change. Therefore, assessing vulnerability to climate change and anticipating adaptation options needs to be a critical element of the entire program of the country.

Five socio- economic sectors namely Agriculture (crops + livestock), Forestry, Water Resources, Wild Life and Human Health have been considered in our vulnerability and adaptation assessment. This chapter summarizes results of the impact assessment and possible adaptation options in each of the five sectors. Socio-economic, environmental and climate change scenarios as well as models used in the assessment are also described. It should be noted here that results of the vulnerability and adaptation assessments are preliminary and as such they should not be viewed as technically rigorous and exhaustive. Further work is needed in this area to improve and perfect the assessments.

5.2 Socio-Economic and Climate Scenarios

5.2.1 Population Scenarios

The population of Ethiopia in 1999 is estimated at 61.7 million of which 85% are rural and 15% are urban (CSA. 1999). The density of the population is 47 persons per km^2. By the year 2030, population would increase to 129.1 million. The current annual population growth is 2.92%. This would reduce to about 1.85% between 2025-2030. Projections indicate that the present population will double by 2027. Current life expectancy at birth is estimated at 50.7 years. The structure of the population reflects a high dependency ratio of 48.6% (part of the population in age group 0-14 and more than 65 are economically inactive). Population scenario and projected demographic indictors until the year 2030 are given in Table 5.1 and Table 5.2.

Table 5.1: Projection of Population in Ethiopia

Year/Population in millions	1995	2000	2005	2010	2015	2020	2025	2030
CSA rural population (LV)	47.1	53.7	59.9	66.4	72.9	79.6	85.6	90.9
CSA rural population (MV)	47.1	54.0	61.3	69.1	77.0	84.9	92.4	99.3
CSA rural population (HV)	47.1	54.4	63.1	72.5	82.5	92.9	103.7	114.7
CSA urban population (LV)	7.6	9.4	11.5	13.9	16.6	19.8	23.3	27.2
CSA urban population (MV)	7.6	9.5	11.7	14.4	17.5	21.1	25.2	29.8
CSA urban population (HV)	7.6	9.6	12.0	15.1	18.8	23.2	28.4	34.6
CSA total population (LV)	54.7	63.2	71.4	80.2	89.5	99.2	108.9	118.1
CSA total population (MV)	54.7	63.5	73.0	83.5	94.5	106.0	117.6	129.1
CSA total population (HV)	54.7	64.0	75.1	87.6	101.2	116.1	132.1	149.4
UN total population (MV)**	55.4	62.6	70.5	79.9	90.9	102.9		
World bank total population estimate**	60.3	71.5	84.7	99.7	116.6	135.5		

Source: CSA 1999, The 1994 Population and housing Census of Ethiopia, Results at country level,Volume II, Analytical Report. Befekadu Degefe, etal**, EAE, Annual Report on the Ethiopian Economy 1999/2000. LV= low variant, MV= medium variant, HV= medium variant .

Table 5.2: Summary of Demographic Indicators based on Medium Variant Scenario.

Indicators	1995-2000	2000-05	2005-10	2010-15	2015-20	2020-25	2025-30
CBR/1000	44.17	39.90	36.89	33.62	30.58	27.51	24.63
CDR/1000	14.96	12.60	10.75	9.22	8.03	7.04	6.20
TFR	6.52	5.83	5.34	4.82	4.30	3.77	3.32
Male LE	50.92	53.42	55.91	58.37	60.83	63.13	65.13
Female LE	52.96	55.43	57.93	60.42	62.89	65.34	67.65
GR	2.92	2.73	2.62	2.44	2.26	2.05	1.85
Urban GR (%)	4.38	4.10	4.06	3.88	3.69	3.51	3.35
Rural GR (%)	2.74	2.57	2.35	2.15	1.98	1.68	1.41

Source: CSA (1999). CBR=Crude Birth Rate, CDR=Crude Death Rate, TFR=Total Fertility Rate, LE=Life Expectancy, GR=Growth Rate

5.2.2 Economic Scenario

The country's economy is highly agriculture dependent. Agriculture and allied activities share about 46% of GDP, industry about 11%, and the Services Sector about 43% in 1997/98 (CSA, 1999; NBE, 1999, MEDaC, 1999). The growth of real GDP is estimated at 5.2% for 1995/96, 12.7% for 1996/97 and 6.3% for 1997/98 (CSA, 1999). The average growth rate of Agriculture, Industry, Services and total GDP at 1980/81 constant factor cost over the period 1992/93-1997/98 was 3.4, 7.3, 7.7 and 5.5 percent respectively (MEDaC, 1999). The real GDP per capita for 1998/99 was about 121 USD (NBE, 1999).

It is noted that the economy shows some improvement in the recent past. Future climate change will occur in a changed socioeconomic situation. It is important to take these changes into account when conducting vulnerability and adaptation assessments. Based on some assumptions such as recent trends in economic performance, free market economic polices, population growth, etc projections of economic indicators for Ethiopia until the year 2030 are given in Table 5.3. It is to be noted that the growth of Ethiopian economy is highly influenced by climate variability particularly drought.

Table 5.3: Projections of Gross Domestic Product (GDP) in million Birr at constant 1980/81 factor cost, GDP growth rate in percent and GDP per capita in Birr.

Year/Economic indicators		1994/95	2000	2005	2010	2015	2020	2025	2030
GDP	Low Scenario		16094	19167	22965	27681	33566	40937	50207
	Medium Scenario	13990*	16289	20643	26405	34077	44349	58166	76830
	High Scenario		16483	22254	30509	42426	59755	85112	122403
GDP Growth Rate	Low Scenario		3.5	3.6	3.7	3.9	4.0	4.1	4.2
	Medium Scenario	5.2*	4.7	4.9	5.1	5.3	5.5	5.6	5.8
	High Scenario		6.0	6.3	6.6	6.9	7.2	7.4	7.6
GDP per capita	Low Scenario		253	262	275	292	316	348	389
	Medium Scenario		256	282	316	360	418	494	595
	High Scenario		259	304	365	448	563	723	948

Source: Bedada Balcha, 2000. Socio-Economic Scenarios for Ethiopia. * = actual estimate (not projection)

5.2.3 Environmental Scenarios

The main environmental problems in Ethiopia are soil erosion, deforestation, recurring droughts, desertification, and land degradation as a result of over cultivation and over grazing and loss of biodivesty including wildlife. With the implementation of the Conservation Strategy and the 1994 Environmental Policy of Ethiopia these environmental problems are expected to improve in the course of time.

5.2.4 Baseline Climate

5.2.4.1 Rainfall variability and trend

Baseline Climate was developed using historical data of temperature and precipitation from 1961- 1990 for selected stations. Mean annual rainfall shows large spatial and temporal variation. The distribution of mean annual rainfall over the country is described and illustrated in section 2.4 of Chapter 2 and in Figure 2.4. It is characterized by large spatial variation and ranges from about 2000 mm over some pocket areas in Southwest to about less than 100mm over the Afar lowlands in the Northeast (NMSA, 1996; Ademe, 1998, Workineh, 1987).

Figure 5.1 shows the year to year variation of rainfall over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations. Area averaged rainfall anomalies for northern half of Ethiopia, central Ethiopia and Southwestern Ethiopia are also shown in Figures 5.2, 5.3 and 5.4 respectively. As it can be seen from the Figures the country has experienced both dry and wet years over the last 50 years. Years like 1965 and 1984 were extremely dry while 1961, 1964, 1967, 1977 and 1996 were very wet years. Studies made at NMSA has shown that there is a link been ElNino and LaNina Phenomena and Ethiopian rainfall.

Trend analysis of annul rainfall shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the Northern half of the country and Southwestern Ethiopia. On the other hand an increasing trend in annual rainfall has been observed in central Ethiopia (Figures 5.2, 5.3 & 5.4).

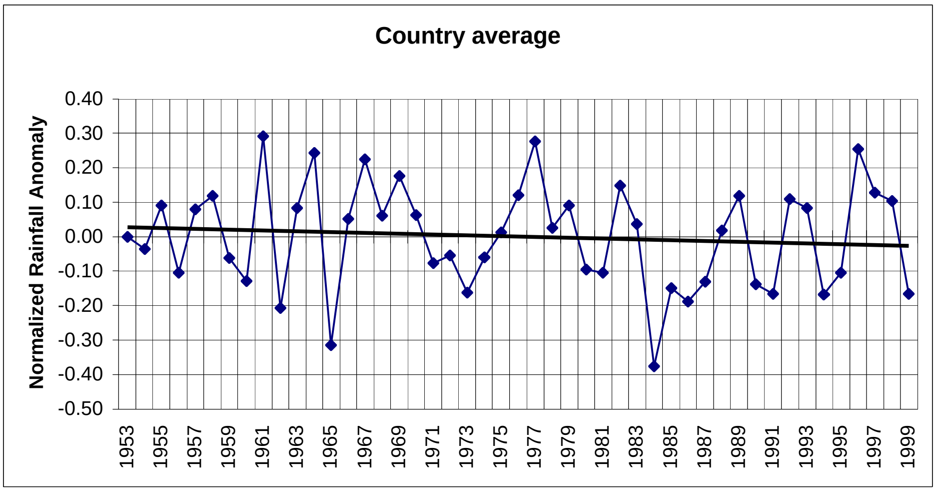


Figure 5.1 Year to Year Variability of Annual Rainfall over Ethiopia expressed in Normalized Deviation.

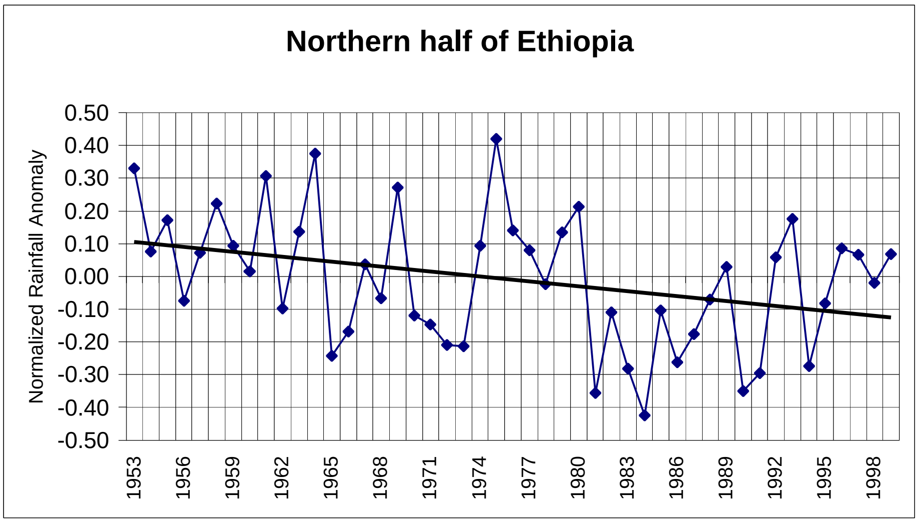


Figure 5.2: Year to Year Variability of Annual Rainfall over Northern half Ethiopia expressed in Normalized Deviation.

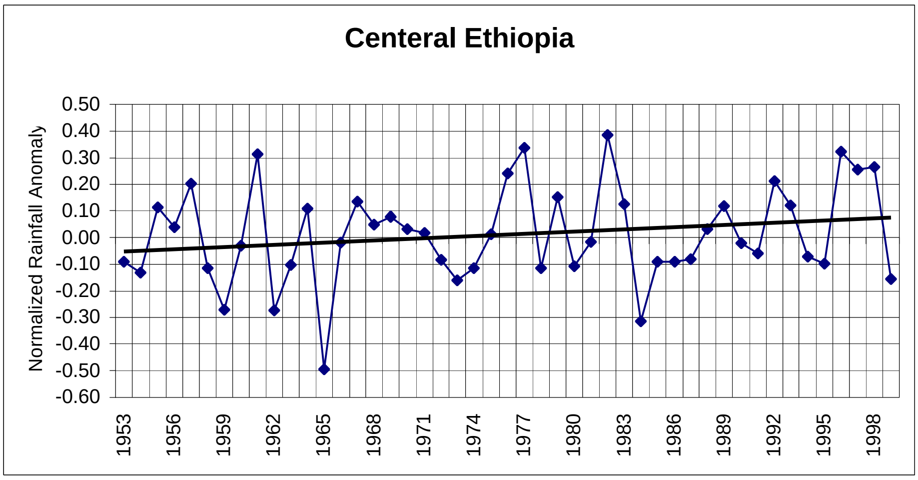


Figure 5.3: Year to Year Variability of Annual Rainfall over Central Ethiopia expressed in Normalized Deviation.

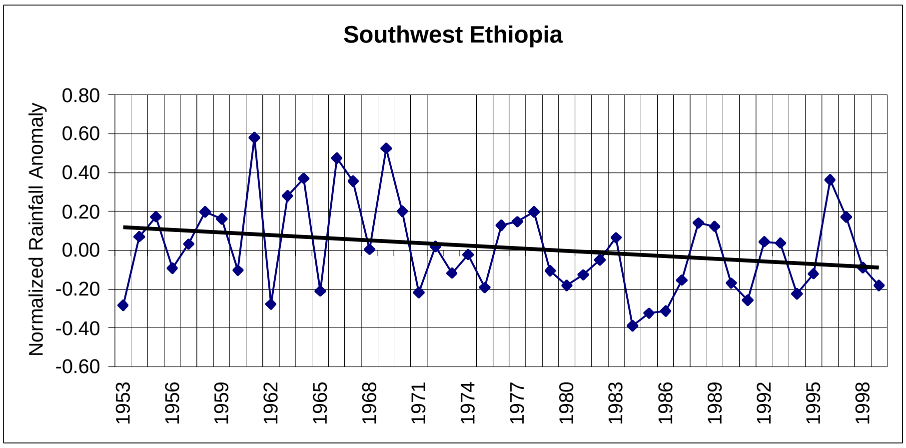


Figure 5.4: Year to Year Variability of Annual Rainfall over Southwestern Ethiopia expressed in Normalized Deviation.

5.2.4.2 Temperature variability and trend

The distribution of annual mean, maximum and minimum temperatures over the country are also discussed in section 2.4 of Chapter 2 and illustrated in Figures 2.5, 2.6 and 2.7. In General the country experiences mild temperature for its tropical latitude because of topography.

The year to year variation of annual maximum and minimum temperatures expressed in terms of normalized temperature anomalies averaged over 40 stations is shown in Figures 5.5 & 5.6. As it can be seen from these Figures the country has experienced both warm and cool years over the last 50 years. Years like 1957, 1958, 1973, 1987 and 1995 were very warm while 1964, 1967, 1968, 1975, 1977 and 1989 were very cool years.

Figures 5.5 & 5.6 also reveal that there has been a warming trend in temperature over the past 50 years. The average annual minimum temperature over the country has been increasing by about 0.25 ^{0}C every ten years while average annual maximum temperature has been increasing by about 0.1^{0}C every decade. It is interesting to note that the average annual minimum temperature is increasing faster than the average annual maximum temperature.

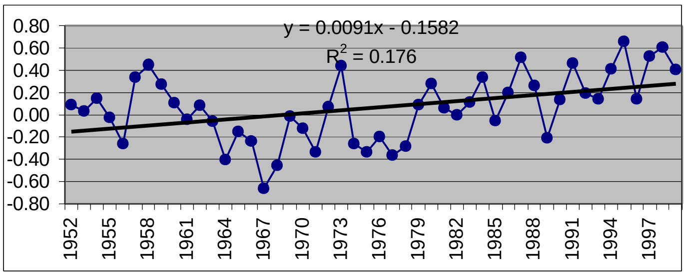


Figure 5.5: Year to Year Annual Mean Maximum Temperature Variability and Trend over Ethiopia

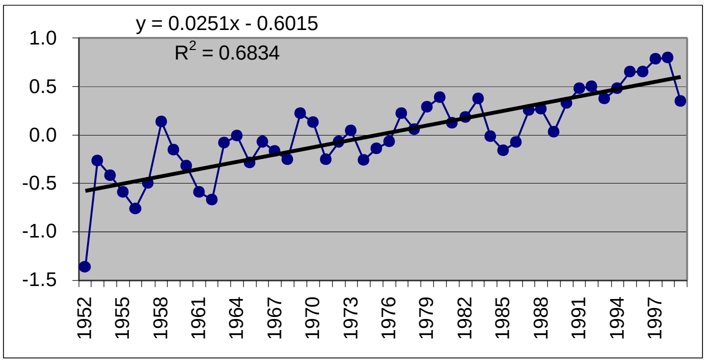


Figure 5.6: Year to Year Annual Mean Minimum Temperature Variability and Trend over Ethiopia

5.2.5 Climate Change Scenarios

Climate change scenarios used in the analysis were developed using three equilibrium and one transient General Circulation Models (GCMs), namely; Canadian Climate Center Model (CCCM), Geophysical Fluid Dynamics Laboratory's model (GFDL), the United Kingdom Meteorological Office-1989 model (UKMO-89), and GFDL-Transient models. In addition Incremental Scenarios were also used.

Table 5.4: Future Climate Projections from Two Equilibrium Models (CCCM, GFDL R-30; for 2075) and One Transient Model (GFDL-transient; for 2070) in Seasonal Time Scale.

Seasons	Projected Temperature Change (^{0}C)
Kiremt	Equilibrium =2.0-3.6; Transient = 0.8-2.4
Belg	Equilibrium=2.0-3.6; Transient =0.5-1.2
Bega	Equilibrium=1.5-3.1; Transient =0.9-1.4

Projections for rainfall did not manifest a systematic increase or decrease. For the Kiremt season, the GFDL gave 10-20% increase for places north of 8 degrees latitude and west of 41 degrees longitude. CCCM projected an increase by about 50% for northern extreme areas. The transient model projected a decrease. For the Belg season, an increase of rainfall by about 5% is projected over Southwest, South and Southeast while a decrease over northern parts is expected by all models. For the Bega season, all models projected a general increase in rainfall.

Incremental scenarios were developed by assuming a 2^0C and 4^0C increase in temperature and change of ±20%, ±10% and no change in rainfall over and above the 1961-90 mean.

Table 5.5: Adjustment Statistics for Doubling of CO_2 as Compared to Current CO_2 Generated by Different GCM for Addis Abeba.

	CCCM		GFDL		UKMO-89	
	T	**P**	**T**	**P**	**T**	**P**
Jan	**2.8**	**0.9**	**2.9**	**1.6**	**2.9**	**0.1**
Feb	**2.9**	**0.8**	**2.7**	**1.0**	**3.3**	**0.5**
Mar	**2.8**	**1.4**	**3.0**	**1.0**	**4.5**	**0.4**
Apr	**2.0**	**0.7**	**2.6**	**1.1**	**4.7**	**0.9**
May	**2.6**	**0.7**	**2.6**	**1.0**	**4.7**	**0.9**
Jun	**2.3**	**1.0**	**3.1**	**0.9**	**4.2**	**1.2**
Jul	**1.9**	**0.6**	**2.9**	**0.9**	**2.8**	**1.2**
Aug	**2.2**	**0.6**	**3.3**	**1.1**	**3.1**	**1.1**
Sep	**2.2**	**1.0**	**3.2**	**1.1**	**3.9**	**1.7**
Oct	**1.8**	**0.7**	**3.1**	**0.9**	**3.7**	**2.8**
Nov	**2.5**	**1.3**	**3.1**	**1.3**	**3.6**	**2.4**
Dec	**2.5**	**1.5**	**2.6**	**0.9**	**3.8**	**2.7**
Annual	**2.4**	**0.9**	**2.9**	**1.0**	**3.8**	**1.3**

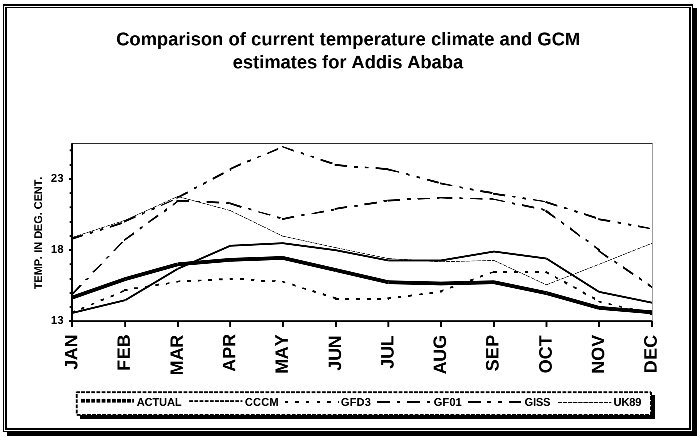


Figure 5.7: Selected Temperature Validation Results of GCMs at Addis Ababa (from Ademe and Kinfe, 2000)

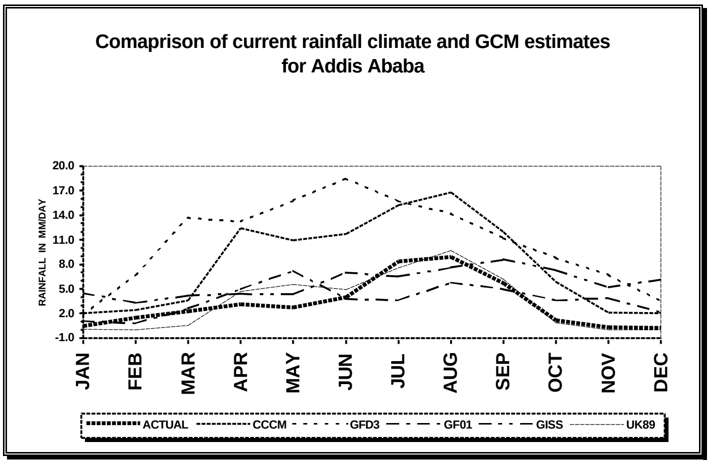


Figure 5.8: Selected Rainfall Validation Results of GCMs at Addis Ababa (from Ademe and Kinfe, 2000)

5.3 Sectoral Impact/Vulnerability and Adaptation Assessment

5.3.1 Crops

Vulnerability assessment in the agriculture sector has been accomplished taking wheat and sorghum, two of the five major crops, as an example.

Wheat

Representative sites selected for the study were Debrezeit ($8^0$45"N/$38^0$59"E), Addis Ababa ($9^0$02"N/$38^0$44"E) from Central Ethiopia and Kulumsa ($8^0$08"N/$39^0$08"E) from Southeast, which are considered as major wheat producing areas in the country. The crop impact is studied using DSSAT V3.0 model. This model is process based comprehensive package that simulates crop phonology, growth, yield and other parameters by integrating the effects of soil, crop cultivar, weather and management options (Rosenzweig et al., 1995). Hence, CERES-Wheat is used for the analysis. Models used for developing the climate change scenarios are CCCM, GFDL R-30 and UKMO (Abebe and Ibrahim, 1999).

Table 5.6 shows the results of the study. Results indicate that crop maturity period would decrease (ranging from –10.6% to-18.5%) under climate change scenarios. A decrease in maturity period by about 16% at Debrezeit and 17% at Kulumsa and Addis Ababa is estimated by the GFDL R-30 model. Also, according to UKMO scenario, a decrease by about 14%, 17% and 19% at Debrezeit, Kulumsa and Addis Ababa is projected respectively. UKMO and GFDL R-30 models projected a decrease while CCCM scenario estimated an increase in yield. The decrease in yield in the GFDL and UKMO scenarios may be associated with an increase in temperature that may significantly shorten crop development stages while yield increase in the case of CCCM climate scenario is not clear at the moment.

Table 5.6: Farm Level Results from Climate Change Scenarios (without Adaptation) at Debrezeit, Kulumssa & Addis Ababa (Change from Baseline is shown as a Percentage).

	Debrezeit		Kulumssa		Addis Ababa	
	Mean yield (T/h)	Mean days to maturity (days)	Mean yield (T/h)	Mean days to maturity (days)	Mean yield (T/h)	Mean days to maturity (days)
Baseline	1.0	104	0.73	118	1.29	124
Percent change under climate change scenario						
CCCM	23	-11	59	-12	13	-12
GFDL	-24	-16	-33	-17	-26	-17
UKMO	-28	-14	-30	-17	-33	-19

Sorghum

The impact of rainfall variability on sorghum yield under different scenarios within the semi-arid areas of Ethiopia has been assessed.

Crop simulation models can quantify the effects of weather, soil properties and crop management on nutrient dynamics and crop growth processes and yield. The first step is to select a model, which is capable of dealing with the major crop production constraints (e.g. soil water and nutrients) and their interaction with management in the most effective way. To deal with these variables, it was clear that a dynamic model was required and a daily time step was the most appropriate. The CERS-Sorghum model met these criteria.

The CERES-Sorghum model was tested with long term field data from sorghum fertilizer research of Melkassa Research Center under variable rainfall conditions. The field trial results indicated that the highest grain and biomass yield were obtained with the low N fertilizer (30 kg ha^{-1}) and further increase in fertilizer rate did not result in further increase in either grain or biomass yields (Kidane and Abebe, 2000). Simulation results of CERES-Sorghum model using the same climatic, soil properties and management practices matched the results of the field trial results accurately.

Then CERES-Sorghum model was used to simulate the incremental progress that might be made on sorghum yield and N uptake at Nazret from implementing different levels (steps) of inputs under variable rainfall conditions. In Step 1, sorghum was grown at low population density without fertilizer N and with high runoff losses in the absence of crop residue return, (representing farmers' practice in the Nazareth area). Step 2 involved a small input of N (15 kg h^{-1}) a small increase in plant population and a return of additional stover produced to the soil. Step 3 involved a further increase in N fertilizer (30 kg N ha^{-1}) plant population and return of stover, while Step 4 had optimal fertilizer (60 kg N ha^{-1}) and plant population (6.6 m^2), with little runoff and is the scenario that represents the production potential for the area.

The model predicted consistent increases in potential grain yield, above ground biomass and N uptake as inputs increased from Step 1 to Step 4. The average sorghum grain yield (1.58 t ha^{-1}) predicted by the model was similar to the long-term average (1.4 t ha^{-1}) reported for the Nazareth area. The strategy analyses indicated that the incidence of crop failure grain yield $\angle$ 300 kg ha^{-1} to be a crop failure was the same for all steps, which is 3 % of the time. With modest inputs in Step 2, the grain yield, biomass yield and N uptake were predicted to be increased by about 60, 69, 78 % respectively compared with step 1. However, total N losses were similar with Steps 1 and 2 (10-kg ha^{-1}).

5.3.1.1 Adaptation options for the Crop sector

Potential adaptation measures to cope with adverse impacts of climate change on crop production could be

- Improving and changing management practices and techniques such as planting date, seeding rate, fertilizer application rate, etc;
- Change in crop regions;
- Proper use of climate information for land use plaping and early warning systems etc.
- Promoting irrigation agriculture;
- Enhancing erosion control;
- Adopting suitable crop varieties and developing new ones;

Table 5.7 indicates that even with fertilizer input, crop yield decreases at all sites except for the case at Kulumsa where CCCM climate projection with fertilizer seems to favor yield.

Table 5.7: Farm Level Results with Fertilizer Additions under Doubling of CO2 at Debrezeit, Kulumsa and Addis Ababa.

	Debre Zeit		Kulumsa		Addis Ababa	
	Mean yield (T/h)	Mean days to maturity (days)	Mean yield (T/h)	Mean days to maturity (days)	Mean yield (T/h)	mean days to maturity (days)
Current climate + Fertilizer	3.7	104	3.07	118	4.53	124
CCCM $2xC0_2$ + Fertilizer (%)	-5	-11	3.7	-12	-5.1	-12
GFDL 2xC02 + Fertilizer (%)	-12.2	-16	-18.8	-17	-17.2	-17
UKMO $2xC0_2$ + Fertilizer (%)	-29.8	-14	-19.6	-17	-22.4	-19

5.3.2 Grassland and Livestock

The lowlands in the Northeast, Southeast, East, South and Southwestern parts of the country also referred to as rangelands (below 1500 meters of elevation) cover about 61-65 % of the total land area of the country. They are home for about 12% of the human, and 26% of the estimated livestock population. About 93% of the people in these areas are pastoralists and agro-pastoralists. Studies show that during the mid-1980s, about 90% of the total exported live animals came from these areas. The lowlands are rich in natural resources including flora and fauna biodiversity. The presence of national parks and wildlife sanctuaries with the respective flora habitats in this part of the country is a clear indication of the resources. Other aspects of the natural resources abundant in the area include aquatics in the form of big rivers and lakes, minerals (metallic and non-metallic) as well as energy in the form of solar and wind. Furthermore, the presence of cultural heritage has made the lowland areas more valuable. It should also be noted that the livestock population over the highlands is considerably high. The highlands cater for grazing areas. Estimated feed requirement of about 15-50% comes from the highlands in the form of crop residues and fallow grazing (Wondwossen and Abay, 1996; Beruk, 2000).

Though, the lowlands are considered to be rich and valuable, there are limitations affecting the resources. Livestock in the area depend on extensive grazing lands. Constraints in the area include socio-economic, environment, structure and policy, and inadequate attention to traditional resource management. In addition to the above, the recurring drought over the areas has become an important issue. The lowlands are normally low-rainfall areas. As drought frequently visits the areas, depletion of pasture and water availability has been a key limiting factor.

The above mentioned factors coupled with climatic variability in the form of shortage and erratic rainfall pattern, recurrent drought, and livestock health risks exacerbated the situation. The compounded negative effect on the resources and the mode of production brought about declining and degradation of the resources, in general, and declining of per capita livestock holdings as well as production and productivity of the livestock, in particular.

Climate change would affect the grassland and livestock sector in many ways such as change in pasture productivity in quantity and quality, change in livestock productivity, change in distribution and incidence of animal and plant disease. Current climate variability and drought is major challenge for this sector. The impact of climate change on grazing land, as a result of temperature increase and shift of rainfall pattern will affect animal production and a decline in the livestock sector will severely affect the economy of the country. In addition the biodiversity inhabiting the areas would be in jeopardy. Therefore, the compounded effect would bring about high degree of vulnerability on the resources as a whole.

Ecosystems and other natural resources in the lowlands and highlands are already under stress. The country is also known for its high animal population (both domestic and wild animals). This indicates that grazing land is under pressure. As indicated above resource degradation is one of the key issues in association with environmental decline. Therefore, additional warming and erratic nature of rains could exacerbate the situation.

5.3.2.1 Adaptation options for the Grassland and Livestock sector

It is to be noted that the coping mechanisms and adaptation strategies in which the pastoral communities have been employing for generations are inclusive of using the traditional skill, knowledge and resource management. In general, however, the adaptation strategies commonly practiced can be broadly categorized into three major areas (Beruk, 2000). These are:

- Improving the survival and productivity level of the livestock and the rangelands;
- Engagement in obtaining food from other sources and income generating activities in times of crises; and
- Scaling down of family members and migration for survival.

Adaptation options recommended for the sector specifically for the highlands and lowlands are listed below (Wondwossen and Abaye,1996; Bruke, 2000).

Adaptation options for the highlands:

- Selection of crops and cropping systems that maximize biomass production and therefore, CO_2 and N_2 fixation;
- Improved animal genotype and better disease parasite control to take advantage of the improved management; and
- Use of multipurpose cattle that work and provide milk and meat and also breed to provide suitable draught animals, in addition to supplying fuel and fertilizer from their excreta.

Adaptation options for lowlands/rangelands

- Strengthening the early warning systems and coping strategies;
- Introduce mixed farming system, where appropriate;
- Destocking of livestock on a regular basis;
- Water resource development in appropriate sites;
- Promote lifestyle choices of pastoralists through access to education and local urban development;
- Rehabilitation of bush encroached areas;
- Conservation and utilization of hay from natural pastures (hay making with local grasses);
- Promotion of herd diversification;
- Promotion of grazing management schemes;
- Use of local legume forage including acacia fruits and leaves;
- Capacity building and institutional strengthening of the local community; and
- Integrated approach to pastoral development.

5.3.3 Forestry

The current forest cover has been simulated using Holdridge Life Zone Classification model. The IISA temperature and rainfall data was utilized for current conditions and GFDL model was used for projecting climate change scenarios. The Holdridge model which correlates climate indices with vegetation distribution was applied over the entire country.

Ethiopia has currently been characterized into nineteen life zones. These are Nival, Alpine, Subalpine wet forest, Montane moist forest, Montane wet forest, Lower montane dry forest, Lower montane moist forest, Lower montane wet forest, Subtropical desert, Subtropical desert scrub, Subtropical thorn woodland, Subtropical dry forest, Subtropical moist forest, Subtropical wet forest, Tropical desert, Tropical desert scrub, Tropical thorn woodland, Tropical very dry forest, Tropical dry forest and Tropical moist forest (Table 5.6 and Figure 5.9).

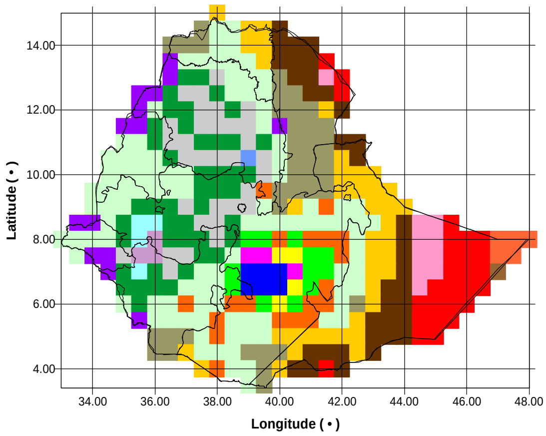
Under changed climate scenarios, changes of forests from one type to another, shifting of forests from old to new habitat, reduction of areas of forest coverage, fragmentation of forest life zones, disappearance of montane and lower montane wet forest and subtropical desert scrub are expected (Negash, 2000). Also appearance of tropical moist forest and expansion of tropical dry and very dry forests are projected. The expansion of tropical desert scrub and tropical dry and very dry forests and on the other hand highly shrinkage of lower montane moist forest in the northern parts of the country could be a result of predicted temperature increase by 2.4^0c-3^0c as well as rainfall decline by about 5%.

Table 5.8: The Potential Holdridge Life Zone Distribution of Ethiopia (From Negash, 2000)

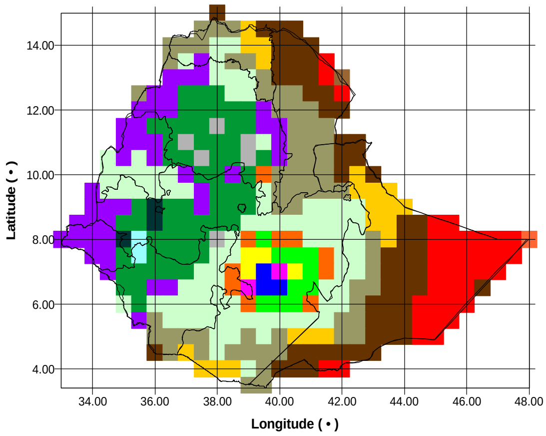
No	Holdridge life zones	Current climate		Climate change (GFDL)	
		Area (ha)	%	Area (ha)	%
1	Nival (Afroalpine)	1,890,755	1.64	945,377	0.82
2	Alpine (Afroalpine)	960,924	0.84	660,228	0.57
3	Subalpine (Subalpine Zone)	1,161,111	1.01	1,320,460	1.15
4	Montane moist (Moist evergreen forest)	3,793,630	3.30	2,971,032	2.58
5	Montane wet (Moist evergreen forest)	360,341	0.31	--------------	-------
6	Lower montane dry (moist evergreen montane forest)	6,085,819	5.29	3,237,176	2.87
7	Lower montane moist (Dry evergreen montane forest and grassland)	10,359,911	9.01	1,980,688	1.72
8	Lower montane wet (Moist evergreen montane forest)	850,814	0.74	------------	-------
9	Subtropical desert (desert and semidesert scrubland)	1,801,627	1.57	360362	0.31
10	Subtropical desert scrub (desert and semidesert scrubland)	2,742,618	2.38	-----------	-------
11	Subtropical thorn woodland (Combretum-Terminalia woodland savanna)	10,289,845	8.95	5,591,948	4.87
12	Subtropical dry forest (Combretum-Terminalia woodland and savanna)	28,026,807	24.37	23,838,291	20.73
13	Subtropical moist forest (Moist evergreen montane forest)	13,873,266	12.06	18,816,543	16.36
14	Subtropical wet forest (Moist evergreen montane forest)	1,631562	1.41	660,228	0.57
15	Tropical desert (Desert semidesert scrubland)	151303	0.13	151303	0.13
16	Tropical desert scrub(Desert semidesert scrubland)	7,206,897	6.27	9,073,156	7.89
17	Tropical thorn woodland (Desert semidesert scrubland)	10,490,032	9.12	14,945,200	13.00
18	Tropical very dry forest (Combretum-Terminalia woodland and savanna)	9,729,306	8.46	16,786316	14.60
19	Tropical dry forest (Combretum-Terminalia woodland and savanna)	3,593,432	3.12	12,754,192	11.09
20	Tropical moist forest	-----------	-----	907500	0.79
	Total	115,000,000	100	115,000,000	100

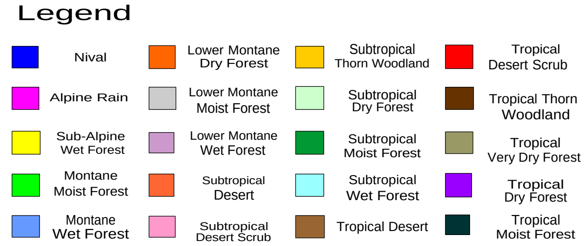
Note: The names in the bracket were given based on the simplified vegetation map of Ethiopia developed by Environmental Protection Authority in collaboration with the Ministry of Economic Development and Cooperation

Figure 5.9: Current Holdridge Life Zones (Based on IIASA Climatological Data base)



Figiure 5.10: Changed Holdridge Life Zones (Based on GFDL Climate Projection)





5.3.3.1 Adaptation options for the Forestry sector

Forests may adapt to the changes in climate on their own, but rates of adaptation could be much slower than the rate of change in climate. Tree species may die out before adapting to the changed climate. Therefore, to minimize the vulnerability of tree species from any climate change effect, anticipatory adaptation measures should be encouraged in contrast to reactive measures as the latter may probably lead to undesired results. Considering the issues that the impact of climate change on the existing forest resources may be irreversible, *i.e.* death, species extinction and loss of valuable ecosystem could occur. Also the costs of reactive adaptation measures could be expensive, thus, adaptation options suggested in the sector include (Negash, 2000):

- Planting trees and establishing plantations;
- Adopting sustainable forest management practices;
- Environmental education and training;
- Maintain untouched forest lands and river banks as migration corridors;
- Promoting conservation/ preservation; and
- Developing disaster resistant tree species.

5.3.4 Water Resources

Vulnerability assessment in the water resources sector has been done on the level of two river catchments, namely, the Awash and the Abay (Blue Nile) rivers.

The Awash river originates in Central highlands and ends in Lake Abe on the Ethio-Djibouti border. It is 1200km long and its catchment area is 113700km^2. The study for this river was accomplished by incorporating the observed climate and hydrologic data and climate change scenarios were developed using GFDL R-30, CCCM and GFDL-transient models (Kinfe, 1999). The water supply (runoff) is projected using the WatBal model. Future water demand from the basin was computed from literatures. The results of the work (Kinfe, 1999) indicates that the Awash River is highly vulnerable to climate change. It is shown that due to population pressure, there is already a water stress even without climate change. Table 5.9 shows the changes in run-off. The results indicate a considerable water deficit ranging from 10 to 33%.

The Abay River starts in the Northwestern parts of Ethiopia, joins the White Nile at Khartoum and ends in the Mediterranean. The study at this basin level focuses on Abay from the start to its course at the Sudan border. The Basin stretches over 201,346km^2 area. As for the study at Awash, CCCM, GFDL R-30, UKMO-89 models were used to develop the climate change scenarios (Deksiyos, 2000). The study indicates that basin is highly sensitive to climate change. Results in table x show that runoff would decrease by 33.6% and 2.6% according to CCCM and GFDL R-30 models, respectively. It is noted that from UKMO projections, runoff changes would increase by 10%.

Table 5.9: Projected Change (%) in Run-Off over the Awash and Abay River Basins Based on GCM Estimates of Temperature and Rainfall for a Doubling of CO_2 and Transient Period Compared with the Present day Runoff (Kinfe,1999 and Deksyos, 2000).

	Doubling of CO_2			
	CCCM	GFDL R-30	UKMO	GFDL-transient
Awash	-33	-10	+40	-27
Abay	-32.6	-2.6	+10	Not available

Incremental scenarios were also employed in the study of the two basins. The results from the effect of the prescribed climate change scenarios (i.e., temperature increase by 2 and 4^0C, and ±20%, ±10, and no change in precipitation) indicate that runoff decreases significantly in warmer and drier scenarios over the two basins. Even a temperature increase by 2^0C without precipitation change would result in a significant decrease in runoff. It is seen that an increase in precipitation would offset the effects of temperature increase.

Table 5.10: Annual Percentage Change in River Runoff based on Prescribed Climate Change compared with the Present-day Runoff (Kinfe, 1999 and Deksyos, 2000).

Temperature changes	Basin	Precipitation (%)				
		-20	-10	0	+10	+20
+ 2^oC	Awash Abay	-41 -34.7	-25 -20.9	0 -5.9	+10 +10.0	+20 +27.1
+ 4^oC	Awash Abay	-43 -39.2	-30 -26.1	-15 -11.7	+4 +4.1	+23 +20.3

5.3.4.1 Adaptation options for the Water Resources sector

No modeling technique has been applied for adaptation assessment in the water sector. Based on expert judgment , possible adaptation options for water resources of the Awash basin include allocation of water supply through market based systems, control of pollution, conservation of water and use of river basin planning and coordination. The adaptation measures suggested above would also apply for the Abay Basin. In addition, adaptation options evaluated in terms of effectiveness for flooding and drought for Abay Basin are presented in Table 5.11 (Kinfe, 1999 and Deksiyos, 2000).

5.3.5 Wildlife

Ethiopia is known for its diversified plant and animal species including high level of endemism in wild plant and animal groups. Estimates of floral endemism for Ethiopia ranges between 12 and 15 % from a total of 6,700 plant species recorded for the country.

Table 5.11: Adaptation Evaluation Table for Water Resources (Abay Basin)

Adaptation Option	Effectiveness for	
	Floods	Drought
Construction of reservoirs for hydropower, irrigation, water supply, flood control and/or multipurpose uses.	High	Medium
Construction of dykes	Medium	-
Use of ground water	-	Medium
Relocation of settlements	Medium	Low
Improvement of water supply (pipelines) systems	-	Medium
Afforestation	Medium	Medium
Improvement of water management system	Medium	Medium
Establish flood forecasting and drought monitoring system	High	Medium

Also of the 277 terrestrial mammals found in Ethiopian, 31 are endemic to the country 20 of which are highland forms. The country is home to many endemic bird species. There are 862 bird species recorded in Ethiopia, of which 261 species or 30.2% are species of international concern. Also of 862 bird species 16 are endemic to Ethiopia and the other 14 are endemic to both Ethiopia and Eritrea. This is a higher avian endemism than any other country in mainland Africa. There are 214 pale-arctic migrant species occurring in Ethiopia of which a total of 47 species are found to over-summer in Ethiopia.

Generally, Ethiopia holds 5 endangered, 12 vulnerable, and 14 near threatened species. There are about 63 sites, globally recognized as endemic bird areas in Ethiopia of which the main ones are: Central highland, Southern highland and Juba-Sheballe Valley. The Abijata- Shalla Lakes National Park (Southern Rift Valley) has also been proposed as a park for the high diversity of water birds. It is also estimated that at least 6 reptiles and 34 amphibians are endemic.

The availability of food, shelter, water and essentials of life determine the carrying capacity of a habitat. The availability of these is in turn climate dependent. Irrespective of its nature, climate change together with human impacts could cause changes to the integrity and distribution of the region's fauna and flora. Shifting of biomes resulting from increased temperatures may reduce the country's fauna and flora diversity, as only species adapted to a wide range of conditions will survive. Also disease is likely to be prevalent to cause problems for wildlife. Projected future changes in climate (See section on scenarios), therefore, could jeopardize the normal life of species of wildlife.

The causes for faunal and floral losses are habitat destruction, induced species, population pressure, pollution, over-exploitation and global climate change. In addition to these it is to be noted that habitat or ecosystem destruction or fragmentation, is the major cause of species depletion or extinction.

A change in climate could threaten migratory species as a result of wetland loss, change in the timing of seasons and sea level rise, which will result in destroying bird's feeding and nesting grounds. Ecosystems, at all their stages, are made up of multitude of animals and plant population, each one either increasing or decreasing or in a fluctuating steady state. They are complex systems whose structure and function are influenced by climate.

Expert judgement also shows that climate change could impact wildlife through changes such as habitat and its biomass productivity, physiological responses of individual organisms, species distribution from one type to another, disappearance of some species, etc.

In general, endemic and threatened species of fauna and flora are frontline victims to climate change as only species with wider habitat and feed requirements have more chance to adapt.

5.3.5.1 Adaptation options for the Wildlife sector

Animals, plants and other ecosystem biotic components may modify their behavior or may migrate to new locations as response to changes in habitat that results from changes in climate. Organisms are adapted to live under only a certain range of climatic conditions and the geographic ranges of many species are highly correlated with climate. In Ethiopian context, wild ass (*Assinus africanus*) is living in and around Denakil Depression (Northeast), adapted to extreme hottest areas, which is 157 meters below Sea level. Ethiopian wolf (*Canis simensis*), Walia Ibex (*Capra walie*) Gelada baboon (*Threopithecus gelada*) are adapted to the extreme coldest areas of Bale (Southeast) and Semen Mountains (North), which is 4,377-4,620 meters above Sea level. These animals live and breed in the two geographical and climatic extremes of the country, where others have their own ecological preferences to adapt. Species with a narrow resource/habitat requirements and inflexible biology would be most vulnerable to climate change and would be most threatened by climate change. Similarly, endemic and threatened species of the country such as Gelada baboon (*Threopithecus gelada*) are expected to be more vulnerable or frontline victims to climate change.

Adaptation or adjustments of organisms may differ based on their physiological make-up, motility or how fast or slow they can migrate, reproductive styles, habitat preferences/requirements (narrow vs. wide), dietary requirement, resistance to disease, biological flexibility etc. However, considering the expected change in climate, the following options can be considered as part of the adaptation strategy (Fetene, 2000):

- Avoiding habitat destruction and fragmentation;
- Protect and enhance migration corridors or buffer zones;
- Increase public awareness about the use of wild life;
- Improve wildlife and ecological surveillance systems;

- Improving land use planning;
- Improve farming and husbandry practices;
- Avoid induced species;
- Minimize population pressure;
- Reduce pollution from industrial effluents;
- Ecosystem, wetland, watershed conservation, preservation and protection;
- Ensure benefits from wildlife parks and sanctuaries for the local community; and etc.

5.3.6 Human Health

Anticipated increase in temperature and change in rainfall would have direct and indirect impacts on the health sector. It will in particular influence weather and climate sensitive diseases by increasing population of vectors such as misquotes, by increasing heat stress, etc. Vulnerability assessment in this sector has been done by taking malaria as a case study. No modeling technique has been applied, instead a synopsis of conditions has been made and how the situation could become worse is anticipated with the change in climate.

Malaria in Ethiopia is a major public health problem. It occurs in most parts of the country and is unstable in its nature mainly due to topographical and climatological conditions. Because the transmission of malaria is dependent on temperature, rainfall and humidity, we have selected it as indices to assess vulnerability of human health in relation to climate change (Mesfin and Tarekegn, 2000).

In the recent past, six major epidemics have occurred in 1958, 1965, 1973, 1981-82, 1987-1988 and 1997-1998. In 1958 a notable epidemic occurred. Since 1958, major epidemics of malaria occurred at intervals of approximately 5-8 years, but recently there is a trend of more frequent small- or large-scale epidemics occurring in the same or different parts of the country. Currently, there are a number of epidemic precipitating factors in addition to natural environmental or climatological factors including chloroquine- resistance of falciparum malaria, high-scale population movement (due to resettlement and labor forces in agro-industrial development areas) and expansion of developmental activities such as irrigation schemes. In 1998, a large-scale and severe malaria epidemic occurred in most highlands as well as lowland areas in the country.

Climatic, altitudinal and topographic diversities in Ethiopia create micro-and macroclimatic conditions that result in a discontinuous and widespread malaria distribution. Based on the occurrence of malaria the country can be divided into malarious and non-malarious areas. The non-malarious afroalpine zone with an altitude above 2250m is the area where no indigenous transmission occurs. This area comprises 15-20% of the total landmass and is inhabited by about 25% of the total population. The malarious zone, which refers to the land below 2200m makes up 80-85% of the total landmass; roughly a minimum of 25 million people live in this region and are at risk of malaria infection. This zone is further classified into four malaria epidemiological modalities; sporadic transmission, occasional transmission, stable seasonal transmission and stable perennial transmission zones.

With the anticipated increase in temperature and with little increase or slight decrease in rainfall over Ethiopia (see section 5.2.5), the distribution of epidemic malaria could widen.

5.3.6.1 Adaptation options for the Human Health sector

Warming in temperature condition can lead to the spread of malaria. In such a situation, the mortality and morbidity rates could reach epidemic proportions. People living in the under developed world suffer from poor health as a result of unsatisfactory living conditions. These communities are especially vulnerable to climate change as most of the adaptation steps are beyond their resources. Nevertheless adaptation strategies need to be formulated in order to cope with this phenomena. These options should be formulated in a way that they can be utilized.

Therefore, to counter the impact of malaria epidemics due to climate change and global warming the following adaptation options may be adopted (Mesfin and Tarekegn, 2000):

- Establish and strengthen surveillance system;
- Promote integrated vector control approach;
- Improve ecosystem management which are sensitive to malaria invasion;
- Planning developmental activities that encompass malaria control;
- Strengthening research in the health sector;
- Educating the public about malaria;
- Encouraging utilization of climate and meteorological information in the planning of malaria control;
- Encourage the use of malaria bed nets; and
- Developing effective malaria drags.

Considering the ever growing threat of global warming, the basic coping mechanism that need to be strengthened and updated in the Ethiopian context is the establishment of an effective surveillance system. The form and structure of this surveillance system should be designed taking local economic realities and resources into consideration.

Chapter 6

POLICIES, PROGRAMS AND MEASURES RELATED TO CLIMATE CHANGE

6.1 Introduction

Although Ethiopia has not yet developed specific climate change policies, programs and measures, there are a number of environmentally oriented policies, strategies and action plans already in place that can directly or indirectly contribute to the objectives of the Climate Convention. Support for the implementation of these policies, strategies and action plans in the form of funding, technical assistance, training and technology transfer through the Convention mechanisms is extremely essential. In this chapter objectives the relevant policies, strategies and action plans are briefly highlighted.

6.2 Conservation Strategy and Environmental Policy

Wide spread degradation of the natural resources and the environment are key problems for Ethiopia. To mitigate these problems, measures are under consideration and various policies and laws are in place. The Environmental Policy of Ethiopia (EPA, 1997a) indicates that environmental sustainability is recognized in policies and strategies as a key prerequisite. In line with this an institution in charge of environmental issues at the federal level, Environmental Protection Authority (EPA), is established. The EPA mainly assumes regulatory role and coordinates various activities within line ministries, agencies and non-governmental institutions. To promote sustainable socio-economic development through sound management and rational use of natural resources and the environment, Conservation Strategy of Ethiopia (CSE) has been formulated (EPA, 1997b). The CSE encompasses 10 sectoral and 10 cross-sectoral environmental policies and seeks to integrate into a coherent framework plan, policies and investment related to environmental sustainability. The CSE stresses on community participation and is firmly placed on both bottom up and top down approaches. The Environmental Policy of Ethiopia also includes policy implementation issues like institutional coordination, legislative framework and monitoring, evaluation and policy review provisions.

Sectoral environmental policies include, among others, sustainable agriculture, forestry, biodiversity, water resources, energy resources, and environmental health. Climate change and atmospheric pollution forms the 9^{th} priority of the sectoral Environmental Policy. The major overall objectives of this policy are to:

- Promote climate monitoring programs as the country is sensitive to changes in climate;
- Recognize that a firm and demonstrable commitment to the principle of containing climate change is essential and to take appropriate measures for a moral position from which to deal with the rest of the world so as to bring about its containment by those countries which produce large quantities of GHGs; and
- Foster use of hydro, geothermal, solar and wind energy so as to minimize emission of GHGs.

6.3 Population Policy

The main objectives of the National Population Policy of Ethiopia (NPPE) are to:

- Harmonize population growth with the country’s natural resources such as land, forest, water, etc;
- Reduce fertility rates through information, education and communication (IEC) strategies and community-based distribution (CBD) programs of contraceptives; and
- Reduce mortality through the promotion of maternal and child health programs.

Within this framework, the NPPE, by 2015, hopes to see the reduction of total fertility rate from the current 7 to 4; increment of contraceptive prevalence rate from the current 4 to 44; and reduction of infant and child mortality rates.

6.4 Science and Technology Policy

The Ethiopian Government issued the National Science and Technology (S& T) policy in December 1993. The objectives of the policy inter alia include building national capability to generate, select, import, develop, disseminate and apply appropriate technologies for realization of the country’s socio-economic development objectives and to rationally conserve and utilize its natural and manpower resources. Although the policy does not address climate change issues explicitly, the policy directives and strategies have duly addressed issues related to rational and efficient utilization of the natural resources and protection and conservation of the environment, both of which are closely related to climate change mitigation and adaptation measures. Then major strategies devised and the priority areas identified in the National S & T policy include:

- Formulation and implementation of S &T plans, programs and projects to accelerate the country’s socio-economic development; self-sufficiency in food production and satisfying the need for other basic necessities with due attention to environmental protection;
- Application of S & T for awareness and control of environmental conditions and for the conservation and rational utilization of the natural resources of the country;
- Develop the capacity and the mechanism to search, choose, negotiate, procure, adapt and exchange technologies that are appropriate and environmentally sound to the Ethiopian socio-economic conditions (this capacity would have an immense importance in acquiring technologies for climate change mitigation and adaptation measures);
- Facilitate Research and Development (R & D) programs that would help to discover, popularize and develop fast growing, drought resistant and multipurpose tree species so as to rehabilitate and develop degraded environments;
- Strengthen technologies that would help to follow up changes in the environment and to forecast, prevent and minimize the effects of natural disasters;
- Support techniques that would help the search and use of alternative and renewable sources of energy; and

- Encourage and support strategies for efficient and economical use of energy in all sectors.

All these S & T policy aspects relevant to climate change have been further elaborated in the sectoral S & T policies which are envisaged to be implemented through the various institutions of the socio-economic sectors.

6.5 Energy Policy

Ethiopia's energy consumption is predominantly based on biomass energy sources. An overwhelming proportion (94%) of the country energy demand is met by traditional energy sources such as fuel wood, charcoal, dung-cakes and agricultural residues. The balance is met by commercial energy sources such as electricity and petroleum. The most important issue in the energy sector is the supply of household fuels.

To improve the energy supply and efficiency of energy utilization the government of Ethiopia has formulated a national energy policy. The general objectives of the energy policy are to:

- Ensure a reliable supply of energy at the right time and at affordable prices, particularly to support the country's agricultural and industrial development strategies;
- Stream line and remove bottlenecks encounter in the development and utilization of energy resources;
- Set general guidelines and strategies for the development and supply of energy resources;
- Give priority to the development of indigenous energy resources with a goal towards attaining self sufficiency;
- Increase energy utilization efficiency and reduce energy waste; and
- Ensure that the development and utilization of energy is benign to the environment.

To achieve the above policy objectives the government had issued a national energy sector policy in 1994. The policy document stipulates that alternative energy sources and technologies shall be developed to meet increasing demand and encouraged and supports adoption of renewable energy technologies. It also encourages and support rational and use of modern fuels and, introduction of energy conservation and energy saving measures in all sectors. The national energy policy also clearly states that development and use of energy resources shall give due consideration to the protection of the environment.

6.6 Agricultural Policy

The main objectives of the draft agricultural policy of Ethiopia are to:

- Increase the production of food crops both in quality and quantity in order to attain food self sufficiency;
- Improve the livelihood of the rural community through sustainable development of the agricultural sector;

- Promote the production of sufficient agricultural products, which can be used as raw material for the agro-industries and to expand the production of industry led agricultural production; and
- Ensure sustainable agriculture through the promotion of agricultural practice, which realizes the conservation of natural resources base.

6.7 Water Policy

Ethiopia is often referred as “the Water tower of East Africa” because of its many rivers and water systems that drain neighboring arid countries. Estimates show that the surface water potential is about 111 billion m^3, which represents a significant per capita. Major problem in developing this enormous resource is limited capacity and uneven distribution of the resource itself. As result of this, the country did not use its optimal irrigation potential and other uses that can be derived from the resource. Even not a significant portion of the potential is utilized for power generation. Therefore, the water policy aims at equitable, sustainable and rational development of the water resources potential. In this policy, issues such as drought mitigation are addressed.

6.8 Forestry Action Plan

The contribution of the forestry sector to the national GDP is very small in Ethiopia (about 6.3%). The rate of deforestation is at an alarming stage in Ethiopia. To enhance the economic contribution of the forestry sector and to mitigate deforestation, “Ethiopian Forestry Action Plan (EFAP) ” has been formulated. It is to be noted that forests serve as carbon sinks and hence enhancement of forestry is a measure that contributes towards the mitigation of GHG emissions.

The main objectives of EFAP are:

- ❖ Increasing sustainable tree and forest products;
- ❖ Increasing agricultural production through reduced land degradation; and
- ❖ Conserving forest ecosystems, genetic and wildlife resources.

To achieve the above objectives, a series of complementary development programs that are classified as primary and supportive have been elaborated in the EFAP.

The primary programs are:

- The tree and forest production program;
- The forest resource management program;
- The forest development program; and
- The wood fuel energy development program, all of which are directly linked to actions to mitigate climate change.

6.9 Disaster Prevention and Preparedness and Early Warning Policy

The Disaster Prevention and Preparedness and Early Warning Policy aims at reducing impacts of disasters through programs which generate employment, environmental rehabilitation and other drought-lessening activities. The main objectives of the Policy are to:

- Ensure that relief efforts reinforce capabilities of affected areas and people; and
- Promote self-reliance and contribute to sustainable economic growth and development.

The policy emphasis that public participation is central in planning, programming, implementing and evaluating relief programs and related measures.

6.10 Health Policy

More than 80% of the common diseases are infectious and communicable, which is mainly due to the poor standard of housing, the lack of potable water and inappropriate disposal of waste. The Ministry of Health considers its responsibility for strengthening the preventive health service among issues requiring top priorities. Thus, the long term health service strategy is to as much as possible concentrate on prevention of common infectious and communicable diseases. Such goals will be achieved mainly through promotion of environmental hygiene that includes safe disposal of waste and minimizing environmental pollution.

6.11 Solid Waste Management Plan of Addis Ababa City Council

The City Council of Addis Ababa considers its responsibility for solid waste management among issues requiring top priorities and gives due attention to up-grade solid waste management and reinforce the legal aspects as regards to beautification and environmental protection in the city.

Chapter 7

RESEARCH AND SYSTEMATIC OBSERVATION

7.1 Climate, Atmospheric & Hydrological Monitoring and Databases

Climate research and monitoring are also commitments Parties have under the Climate Convention. The responsibility to monitor climate in Ethiopia lies on the National Meteorological Services Agency (NMSA). Currently a network of about 629 (125 principal + 185 ordinary + 319 raingauge) meteorological/ climatological stations are run by NMSA nationwide. NMSA also maintains an upper air sounding station and primary data receiver systems for METEOSAT and NOAA satellites at Addis Ababa. Currently there are no greenhouse gas and ozone monitoring stations in the country.

NMSA provides routine information on current climate conditions in the country including monthly and seasonal climate outlooks. Ethiopia actively participates in the World Weather Watch (WWW) program of the WMO by providing daily weather observations from 18 synoptic stations which are disseminated worldwide for use in climate and weather prediction. Ethiopia also cooperates with regional organizations such as the African Center for Meteorological Applications and Development (ACMAD) and the Nairobi based Drought Monitoring Center (DMC) in the field of climate and Meteorology.

Hydrological monitoring in Ethiopia is carried out by the Hydrology Department of the Ministry of Water Resources. Currently there are about 338 operational stream gauging stations distributed over the major river basins (Kidane Asefa, 1997).

Data base on energy use and energy balance is maintained by the Ethiopian Rural Energy Promotion Center (EREPC) of the Ministry of Mines and Energy. An inventory of the woody biomass resources of Ethiopia has been undertaken by the Ministry of Agriculture since 1990 under the Woody Biomass Inventory and Strategic Planning Project (WBISPP). It is expected that the outcome of the Project will provide up-to-date and reliable information on the forest resources of the country. The Central Statistical Authority (CSA) is also one of the main government organ in collecting data and developing databases in Ethiopia.

It should be noted that the existing climatological and hydrological observation network in the country is far from being adequate. The management of the climatological, hydrological and other databases relevant to climate change also needs strengthening and the government of Ethiopia is making efforts towards this end.

7.2 Climate Research

One of the mandate given to NMSA is to carry out research and studies in the field of Meteorology and the Agency implements this task through its Meteorological Research and Studies Department. So far significant progress has been made in understanding the weather and climate of the country. Topics such as Assessment of Drought and its Impact in Ethiopia, Weather Systems over Ethiopia and its Neighborhood, Temperature and Rainfall Trends, Climatic and Agro Climatic Resources of Ethiopia, Rainfall Variability and its Relation to El Nino Phenomena, Application of Satellite Data in Rainfall and Vegetation Monitoring, etc have been covered. A number of study reports, publications and maps have been produced on these topics.

With the exception of limited activities at the Department of Geography of the Addis Ababa University, Ethiopian Agricultural Research Organization and the Arbaminch Water Technology Institute, graduate and undergraduate courses/programs including research in Meteorology and Climatology are virtually absent in higher education and research institutions of the country.

Since the issues of climate change are relatively new, research in the field is also limited in the country. However the following steps have been taken.

- A Team has been established under the Research and Studies Department of NMSA to co-ordinate and carry out research on climate change issues in the country since 1994.

- A Climate Change Country Study project was undertaken from 1993-1996 with a financial and technical support of the US government. In this project preliminary studies on greenhouse gas emissions and climate change impacts on various socio-economic sectors was undertaken in co-operation with stakeholder institutions.

- Ethiopia has been participating in the GEF supported Climate Change Enabling Activities Program since 1998.

Chapter 8

EDUCATION, TRAINING AND PUBLIC AWARENESS

The importance of Education, Training and Public Awareness in dealing with the challenges of climate change are well recognized by the Convention as stated in its Article 4 and Article 6. Ethiopians need to be made well aware about the commitments of the country under the Convention, the impacts of climate change, adaptation and mitigation options as well as about measures that can be taken at the individual level to combat climate change. In line with this NMSA as a focal institution has made the following efforts during the last few years in order to increase general awareness and technical skills in climate change**.**

- A number of articles on climate change have been produced on newspapers, magazines and newsletters. It is worth mentioning that Agazen, a bi-annual environmental newsletters/bulletin published and distributed freely to high school students by EWAS, featured climate change prominently in one of its issues.
- Talks about climate change have been given in many environmental clubs established in secondary schools, teacher training institutions and in environmental forums organized by NGOs as well as in distance education programs by radio of the Ministry of Education.
- Several technical and non-technical workshops and seminars on climate change have been organized at the national level.
- A number of national experts have been made to participate in training workshops, seminars organized abroad including IPCC plenaries and sessions.
- Interviews and public releases on climate change have been given on television and radio.
- The texts of the UNFCCC and the Kyoto Protocol have been translated in Amharic, the official language of Ethiopia, in a summarized form.
- A half-day workshop on climate change for local journalists was organized in collaboration with The PANOS Institute.

The Ministry of Education (MoE) has also made efforts to introduce Environmental Education in the school curricula at various levels. Topics on climate change have been infused with subjects like Geography, Agriculture and Biology.

Despite these efforts the level of awareness about the environment in general and climate change in particular is still very low among most Ethiopians. Graduate and undergraduate courses/programs including research in climate change are not yet included in the education system of relevant higher education and research institutions of the country. Climate change is a new and complex issue. Decision makers, professionals and the public at large should be made aware about climate change. Training is also a necessity to implement climate change programs and polices. The effort to raise awareness, to create educated and skilled experts to handle climate change issues should continue through various means such as

- Production of articles, interviews, through the mass media;
- Developing climate change web-site and networking;

- Organizing a series of targeted workshops/seminars/ panel discussions;
- Preparing and widely disseminating information and teaching materials as well as fact sheets on climate change including the Initial National Communication of Ethiopia to the UNFCCC;
- Launching climate change courses in universities, teacher training institutions and secondary schools;
- Short and long term training of national experts in the various aspects of climate change, etc.

Chapter 9

FINANCIAL, TECHNOLOGICAL AND CAPACITY BUILDING NEEDS AND CONSTRAINTS

9.1 Introduction

The Convention very well recognizes the need for the provision of financial and technical support including technology transfer and capacity building for developing country Parties to fully participate in the implementation of the Convention. As a least developed country Party, as a country which is prone to drought, desertification and other natural disasters, as a country which is land locked and as country which has large proportion of arid and semi-arid land as well as a fragile mountainous ecosystem, Ethiopia needs a special consideration in this respect as stated in article 4,8 and 4.9 of the Convention. This section highlights Ethiopia's priority in the areas of financial technical and capacity building needs to meet her commitments under the UNFCCC.

9.2 Data Collection and Monitoring

Data generating, gathering, archiving and analyzing capability of the country, which is week at the moment, needs to be enhanced. Climatological, hydrological, ecological, biodiversity/ wildlife and landuse/landcover monitoring are all essential in dealing with climate change. Relevant institutions such as Ministry of Agriculture, Central Statistical Authority, Ministry of Mines and Energy, Ministry of Water Resources need to be strengthen in this respect in terms of manpower, training, and facilities.

Of particular importance is strengthening of the national meteorological and hydrological services of the country by

- Improving the density of the climate and hydrological station network through the establishment of new observation stations and rehabilitating existing ones;
- Improving the communication system for data collection;
- Modernizing data base systems including quality control; and
- Short and long term training of staff to maintain the service.

Capacity building in data collection and monitoring will improve the country's ability to produce timely and well processed data to meet the requirement of different users including the supply of data for climate change studies. The country also will have the capacity to be better prepared for extreme events such as drought and to effectively and properly apply climate and hydrological information in decision making and socio- economic development planning.

9.3 Training

Skilled human resource development to handle climate change issues is a priority for Ethiopia. There is a need to develop and implement a training program which contains both short-term and long-term training in the following areas:

- Vulnerability and adaptation assessment;
- Integrated assessment;
- Climate variability, climate change detection and climate modeling;
- Mitigation analysis;
- Adaptation and mitigation costing;
- GHG inventory;
- Mitigation and adaptation technology assessment, transfer and adoption;
- Policy Analysis;
- Program and project development in climate change;
- Formulate and implement adaptation and mitigation action plans;
- Land use planing; and
- Use of satellite remote sensing data, Geographic Information System and statistical analysis techniques.

9.4 Research and Studies

The socio-economic development of Ethiopia is very much influenced by climate and its variability including drought. The IPCC has concluded that climate change will have significant adverse impacts on developing countries.

Ethiopia is concerned about the projected impacts of climate change. It is of utmost importance to carry out vulnerability & adaptation research and studies in agriculture, water resources, forestry, human health, biodiversity including wildlife on a continuos basis in order to establish the level of the country's vulnerability to climate change and identify best adaptation options and polices. Research and studies on current climate variability, particularly extreme climate events such as drought and flood, and its coping mechanisms is also essential.

In this respect strengthening and developing local capacity to conduct climate research both at NMSA and higher level education and research institutions by mobilizing available expertise and creating new ones is vital. The provision of trained individuals with analytical skills to identify and evaluate adaptation options, undertake vulnerability assessment and adaptation planning is highly important.

Other climate change related research and study areas which need attention at the national level are:

- Integrated assessment;
- Climate change detection and climate modeling;
- Mitigation analysis;

- Adaptation and mitigation costing;
- GHG inventory;
- Technology assessment, transfer and adoption; and
- Policy analysis.

9.5 Awareness Creation

As climate change is a new issue the level of awareness among policy makers, professionals and the general public about it is very low in the country. Awareness about climate change is crucial for the implementation of the UNFCCC. Therefore financial support and capacity building to develop and implement climate change awareness program/project is necessary. Awareness creation about climate change can be achieved through various means such as preparing and sending articles for newspapers, giving invited talks/public lectures, organizing a series of targeted awareness workshops/seminars/ panel discussions, preparing and disseminating climate change brochures/newsletters, producing television and radio programs/interviews, strengthening of the NMSA'S public relation service with human resource, developing an Internet web site, etc.

9.6 Development of National Climate Change Network

Institutional linkages and communication have to be strengthened by building a network of stakeholders through electronic means such as the Internet. This will facilitate exchange of information and experience among experts, national, regional and international institutions. Consultation for project/program preparation and implementation will also be enhanced if there is fast communication means.

9.7 Strengthening of the National Focal Institution

The National Meteorological Services Agency is the focal institution for coordinating climate change issues in the country. The Climate Change and Air Pollution Studies Team of the NMSA is responsible to follow up the day to day routine and research activities in climate change. At the moment the Team has only three staff. It needs to be strengthened in terms of manpower, training and facilities to better coordinate climate change issues in the country.

Financial support and capacity building to develop a documentation and information center under NMSA to enhance the availability of relevant climate change materials for various audiences will be essential.

The participation of the country in the climate change negotiation process is weak due to lack of financial support and inadequate negotiation and language skills. So far financial support for climate change negotiations has been made available through the UNFCCC secretariat only for the participation of one delegate from the focal institution in UNFCCC formal negotiation sessions.

Since climate change is a complex and multi-disciplinary issue it is essential if relevant lead ministries also participate in the climate change negotiations. Adequate financial support is needed to send large enough delegation to cover the important aspects of the Convention meetings.

Delegation of Ethiopia needs to get training in negotiation skills in the various aspects of the Convention including recent issues such us the Clean Development Mechanism (CDM) as well as in the preparation of key position papers in order to enable them participate effectively and meaningfully in climate change negotiations.

9.8 Mitigation Activities and Technology Transfer

As a party to the UNFCC Ethiopia is willing to contribute to the achievement of the ultimate objective of the Convention despite her very low contribution to the global GHG emissions. There are a number of potential mitigation options/ opportunities, which could meet both objectives of socio-economic development and climate protection. Ethiopia needs to identify and implement these options with the provision of financial, technical and technological support from developed countries. Identified potential areas/options for financial support, technology transfer and project development in GHG mitigation are given in Table 9.1.

Table 9.1 Potential areas/options for financial support, technology transfer and project development in GHG mitigation.

No	Sectors/Sub-sectors	Mitigation options/technologies
1	Energy • Energy Industries • Manufacturing Industries and Construction • Transport • Commercial/Institutional • Residential • Agriculture/Forestry/Fishing	• Promoting the use of renewable energy (Ethiopia could contribute to GHG mitigation by developing and exploiting her huge hydro, solar, wind, biomass and, geothermal energy resources not only for her own consumption but for neighboring countries as well.) • Dissemination of solar, wind and biogas energy technology; • Replacement of diesel generators by hydropower mainly in urban centers • Improving/promoting energy efficiency and conservation e.g. wide dissemination of improved biomass and charcoal stoves, such as 'Mirt Mitad and lackech' • The promotion of the use of smaller cars through tax differentiation based on engine size • Expansion of public transport infrastructure • Improving the efficiency of operating vehicles by carrying out maintenance, inspections and training • Improving urban traffic • Promoting environmentally friendly transport modes such as bicycles • Promote the use of fuels with low carbon content (fuel switching) e.g. exploiting the Ogden natural gas reserve for various purposes including cars • Use of gasohol (blending of ethanol with gasoline) for cars i.e. supply side management • Introduction of improved stove (i.e. demand side management) • Substitution of photo voltaic (PV) lanterns for kerosene lighting i.e. supply side management

2	Industrial Processes	
3	Land-Use Change & Forestry	• Improving forest management practices • Protection/preservation of existing forests from loses by deforestation and other practices • Initiate new afforestation and reforestation programs • Rehabilitation of degraded forests • Promoting agro-forestry • Using biomass as a substitute for fossil fuels through the production of woody biomass. • Developing and restoring gallery forests along river banks
4	Agriculture	• Increasing livestock productivity through improved nutrition, strategic supplementation and treatment of forages to improve digestibility and through improved genetic characteristics. • Promoting sustainable agriculture • Promoting mixed crop livestock farming where aproprate • Promoting the use of manure-Management system facilities • Adopting appropriate fertilizer application • The use of conservation tillage techniques to sequester carbon in cultivated soils • Rehabilitation of overgrazed watering points and long-term settlement areas and redistribution of manure that is accumulated near these settlements.
5	Waste	• Integrated waste management • Composting solid waste of Addis Ababa city • landfill gas recoveries from solid waste site of Addis Ababa city

Chapter 10

IMPLEMENTATION STRATEGY AND MONITORING

Environmental degradation is a key issue to the country. Thus, Ethiopia should consider environmental issues in various investment plans and policy formulations. In light of this, an institution in-charge of environmental issues in general, the Environmental Protection Authority (EPA), is established at the federal level. Environmental Policy of Ethiopia, an umbrella policy which is composed of 10 sectoral and 10 cross-sectoral environmental policies, was formulated in 1994 (EPA, 1997). Environmental regulations and legislation are also being formulated and submitted to the Government for approval. The EPA mainly assumes regulatory role and coordinates various activities within line ministries, agencies and non-governmental organizations. The Policy includes implementation issues like institutional coordination, legislative framework and monitoring, evaluation and review provisions.

Among the sectoral environmental policies is Climate Change and Air Pollution. In this context, the NMSA is mandated to deal with this latter issue and implementation of Climate Change and Air Pollution issues falls under its responsibility. A Team has been established under the NMSA to coordinate and carry out research on climate change issues in the country and hence, the present study forms part of the effort to implement the issue. Climate change issues are complex and their handling need multi-disciplinary approach. Continuity in the context of coordination will be the responsibility of the NMSA, but stakeholders will have specific responsibility. There is a need to maintain and strengthen the established Climate Change Steering Committee and the Expert Teams including the Climate Change and Air Pollution Studies Team of NMSA.

REFERENCES

Abebe Tadege and Ibrahim Mohammed, 1999. Crop Vulnerability and Adaptation assessments to climate change. National Meteorological Services Agency, Addis Ababa, Ethiopia.

Ademe Mekonnen and Kinfe Hailemariam, 2000. Baseline and Climate Change Scenarios for Ethiopia. National Meteorological Services Agency, Addis Ababa, Ethiopia.

Ademe Mekonnen, 1998. Interannual rainfall variability over the Horn of Africa. MSc dissertation, University of Reading, Reading, UK.

Adnew Adam, 1999. Inventory on Greenhouse gas emissions from Domestic and Industrial Wastewater in Ethiopia, (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Asress W/Giorgis, Ephrem Hassen, Worku Gosaye and Getachew Worku, 1999. Greenhouse gas emission inventory for the energy sector of Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Barber, R.G., 1984. Assessment of the dominant soil degradation processes in Ethiopian highlands: their impacts and hazards. WP23, Ethiopian Highland Reclamation Study, Ministry of Agriculture and FAO. 56pp.

Befekadu Degefe and Berhanu Nega, The Ethiopian Economic Association. Annual Report on the Ethiopian Economy, Vol.I. 1999/2000.

Berhanu Kibret, 1999. Inventory of Greenhouse gas emissions for the Industrial Processes Sector of Ethiopia, (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Beruk Yemane, 2000. The declining pastoral environment, Vulnerability Status and Adaptation Strategy (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Brenan J.P.M., 1978. Some aspects of phytogeography of tropical Africa. Annals of Missouri Botanical Garden 65: 437-478.

Central Statistical Authority (CSA), 1995, Agricultural Sample Survey for 1994/95, Report on Area and Production for Major Crops, Statistical Bulletin 132, Vol. I 1995 Addis Ababa.

CESEN-ANSALDO/FINMECCANICA Group, 1986. Main Report 1 and Technical Report 1. Ministry of Mines and Energy, Addis Ababa.

CSA (Central Statistics Authority), 1999b. The 1994 Population and Housing Census of Ethiopia: Results at a country level, Vol. II- Analytical report. Office of Population and Housing Census Commission/ Central Statistics Authority, Addis Ababa.

Deksyos Terekegn, 2000. Vulnerability and Adaptation Assessment of Water Resource to Climate Change in the Abay Basin (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Dereje Kebede, Ephrem Hassen, Worku Gosaye and Getachew Worku, 2000. Options for the reduction of greenhouse gas emissions in the Energy sector in Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

EMA (Ethiopian Mapping Authority), 1981. National Atlas of Ethiopia. Berhanena Selam Printing Press, Addis Ababa.

EPA (Environmental Protection Authority), 1997b. The Conservation Strategy of Ethiopia, Vol. II and IV. Environmental Policy. Environmental Protection Authority, Addis Ababa.

Ermias Bekele, 1987. Ethiopia's Land Resource Base: Potentials and Limitations. In: IAR Proceedings, 19th National Crop Improvement Conference, 22-26 April 1987, Addis Ababa, Ethiopia. Institute of Agricultural Research. pp. 37-51

Ethiopian Valleys Development Authority (EVSDA), 1989. Environmental and development issues in Ethiopia from the perspectives of the EVSDA. Addis Ababa.

EWNHS-Ethiopian Wildlife and Natural History Society, 1996. Important Bird Areas of Ethiopia, A First Inventory, .Semayata Press, Addis Ababa, Ethiopia.

FAO, 1997. Forest products Yearbook, FAO.

FAO Production Year Book Vol. 45-51, 1991-1997.

Fetene Hailu, 1999. Wildlife Vulnerability & Adaptation Assessment to Climate Change in Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Fikru Tessema, 1999. Estimation of Methane emitions fom solid waste in Ethiopia a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Fikru Tessema, 2000. An Assessment of Mitigation of Methane Emissions from Solid Waste (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Griffiths, J.F. (ed.), 1972. Climate of Africa, Vol. 10, World Survey of Climatology, Elsevier, Amsredam, 602pp.

Hailu G.Mariam, 1992. Rural Electrification in Ethiopia. In: V.Ranganathan. Rural Electrification in Africa. Zed Books Ltd, 57 Caledonian Road, London N1 9BU, UK, in association with AFREPREN. pp. 67-111

Hurni, H., 1988. Climate, Soil and Water: Degradation and conservation of the resources in the Ethiopian highlands, Part 2. Mountain Res. Development, 8, 2/3, 123-130.

IPCC, 1996. Climate Change 1995: The Science of Climate Change. Houghten, J.T., L.G.M. Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell, (eds.). Cambridge University Press, Cambridge.

Kidane Asefa, 1997. Aspects of Water Resource Monitoring and Assessment in Ethiopia. In: Procedings of the Vth Nile 2002 Confrence, February 24-28, 1997, Ministry of Water Resources, Addis Ababa, Ethiopia.

Kidane Giorgis and Abebe Tadege, 2000. Assessing the impacts of rainfall variability on sorghum yield under different scenarios within the semi-arid areas of Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Kinfe Hailemariam, 1999. Impact of climate change on the water resources of the Awash basin, Ethiopia. Clim. Res., 12, 91-96.

Lemma Gonfa, 1996. Climate Classifications of Ethiopia. NMSA, Meteorological Research

Mesfin Lulu and Tarekegn Abose, 2000.Vulenrablity Assessment & Adaptation Options in the Human Health sector in Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Million Bekele, 2000. Climate Change Mitigation Study in Land Use Change and Forestry in Ethiopia (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

MNRDEP (Ministry of Natural Resources Development and Environmental Protection, Ethiopia), 1994. Ethiopian Forestry Action Program (EFAP). EFAP Secretariat, MNRDEP, Addis Ababa.

MOA (Ministry of Agriculture), 1993. Crop assessment report, Addis Ababa.

NBE (National Bank of Ethiopia), 1999. National Bank of Ethiopia Quarterly Bulletin, Vol. 14, No.4. Addis Ababa, Ethiopia.

Negash Mamo, 2000. Vulnerability and adaptation of Ethiopian forests to global climate change (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

NMSA (National Meteorological Services Agency, Ethiopia), 1996. Climatic and agroclimatic resources of Ethiopia. Addis Ababa. Internal Report. Meteorological Research Report Series, No. 3, Addis Ababa, Ethiopia.

Rosenzweig et al. 1995. Climate Change Crop Modeling Techniques (manual).

Ojima, D., Wondwossen Asfaw, Abaye Tedla, and Menwyelet Atsedu, 1996. Effects of long-term cultivation and grazing on soil carbon storage and plant bio-mass: A simulation approach to two case studies for Ethiopia. The Environmental Professional, Vol.18, Special issue No.1, Blackwell Science, Inc.,Cambridge, MA, USA. pp 125-133.

Solomon Abate, 1994. Land Use Dynamics, Soil Degradation and Potential for Sustainable Use in Metu Area, Illubabor Region, Ethiopia. African Studies Series A13, Berne. 139pp.

Survey of the Ethiopian Economy, 1999. Review of post-reform developments (1992/93-1997/98). Ministry of Economic Development and Cooperation (MEDaC). Addis Ababa, Ethiopia.

Tewolde Berhan Gebre Egziabher, 1991. Diversity of the Ethiopian Flora. In: J..M.M Engels, J.G. Hawkes and Melaku Worede. Plant genetic resources of Ethiopia. Cambridge University Press. pp. 75-81

UNCED National Report, 1992, National Report on Environment and Development, 1992, A report prepared for the United Nations Conference on Environment and Development by the Government of Ethiopia

Woldemeskel G.Mariam, 1998. Information needs for Agricultural Development. In: Proceeding of the Symposium on Utilization and Provision of Information in Ethiopia, 9-11 November 1998, Addis Ababa, Ethiopia, Organized by Walta Information Center, Ethiopian Television, and Ethiopian Science and Technology Commission. pp. 233-264

Wondwosen Asfaw and Abaye Tedla, 1996. Vulnerability and Adaptation assessment to climate change in the grasslands and livestock sector in Ethiopia.

Wondwosen Asfaw and Dagnenet Yemenu, 2000. Greehouse gas inventory and mitigation options in the Agriculture Sector of Ethiiopia, (unpublished), a report submitted to NMSA under the GEF/UNDP supported Climate Change Enabling Activities Project (ETH /97/G31) of Ethiopia.

Workneh Degefu, 1987. Some aspects of meteorological drought in Ethiopia. pp 23-26 In, Drought and Hunger in Africa: denying famine a future, M.H. Glantz (ed.). Cambridge University Press.457 pp

ANNEXES

Annex I

Sectors addressed and Members of the Working Group on Greenhouse Gas Inventory and Mitigation

No	IPCC GHG Inventory categorization	Name of technical expert	Institution
1	Energy	Mr. Asress W/Giorgis (Energy Engineer)	Ministry of Mines and Energy (Ethiopian Rural Energy Development and Promotion Center)
		Mr. Ephrem Hassen (Energy Planner/Economist)	”
		Mr. Dereje Kebede, (Mechanical Engineer)	”
		Mr. Worku Gosaye (Petroleum Engineer)	Ethiopian Petroleum Enterprise
		Mr. Getachew Worku (Transport Economist)	Ethiopian Road Transport Authority
2	Industrial Processes	Mr. Berhanu Kibret (Chemical Engineer)	Ethiopian Chemical Society
3	Land-use & Forestry	Mr. Million Bekele (Forester)	Ministry of Agriculture Forestry Wild life, Soil, Land Use Technology Control Department
4	Agriculture	Dr. Wondwosen Asfaw/ Dr. Dagnenet Yemenu (Livestock Experts)	Ministry of Agriculture, Livestock and Fisheries Development and Veterinary Technology Control Department
5	Waste	Mr. Fikru Tessema (Waste Management Expert)	Addis Ababa Health Bureau
		Mr. Adnew Adam (Environmental Technologist)	Addis Ababa Water and Sewerage Authority

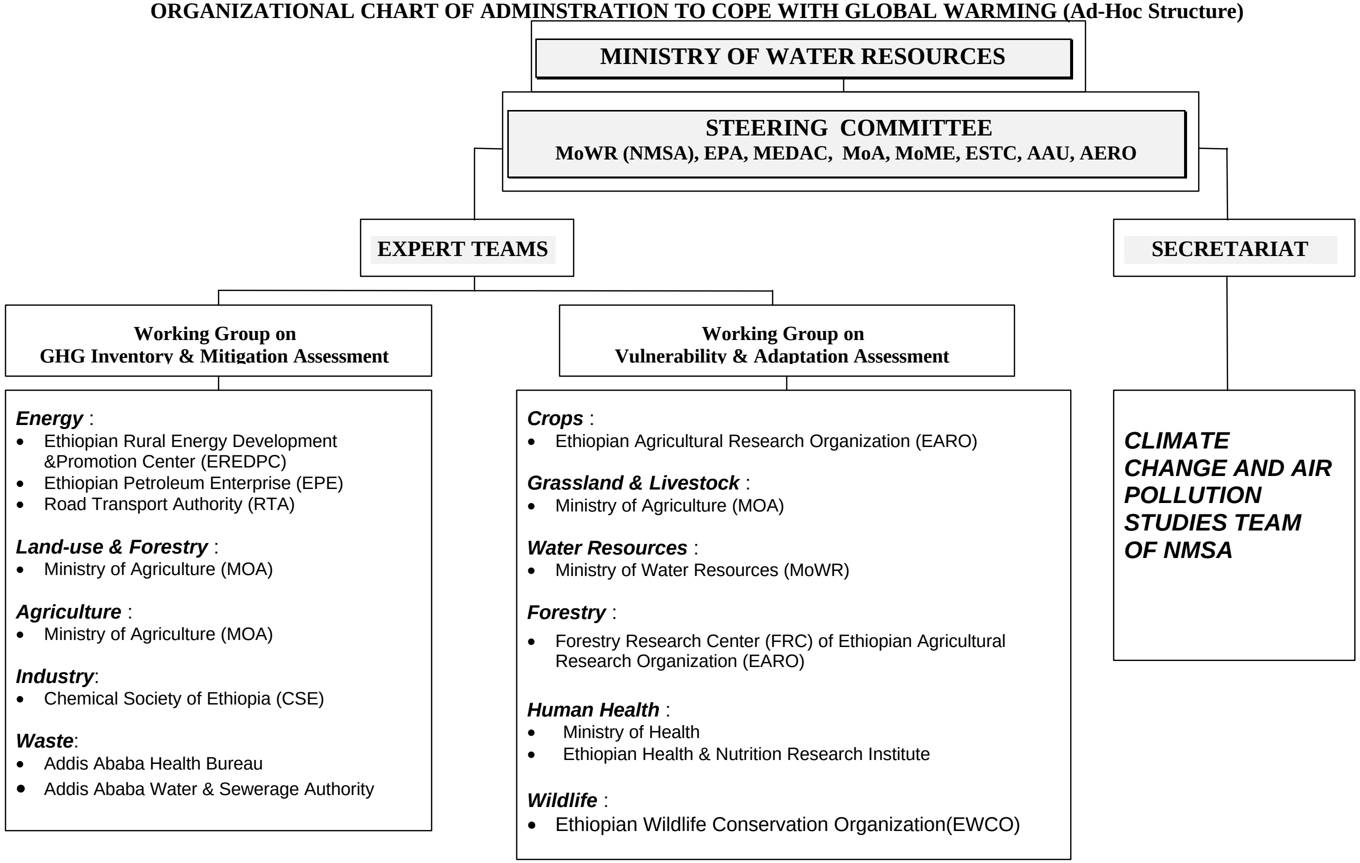
Annex II

Sectors addressed and Members of the Working Group on Vulnerability and Adaptation

No	Area of responsibility	Name of technical expert	Institution
1	Crops	Dr. Kidane Georgis (Agronomist)	Ethiopian Agricultural Research Organization (EARO)
2	Livestock/ Grassland	Mr. Bruke Yemane (Rangeland Expert)	Agriculture Extension Department (MoA)
3	Forestry	Mr. Negash Mamo (Forester)	Forestry Research Center
4	Water Resources	Mr. Deksyos Tarekegne (Hydrologist)	Ministry of Water Resources, Department of Hydrologist
5	Human Health	Mr. Tarekegne Abose (Epidemiologist)	Malaria and Vector Born Diseases Control Department, Ministry of Health
		Mr. Mesfin Lulu (Epidemiologist)	National Health and Nutrition Research Institute
6	Wild Life	Mr. Fetene Hailu (Biologist)	Ethiopian Wildlife Conservation Organization

Annex III

ORGANIZATIONAL CHART OF ADMINSTRATION TO COPE WITH GLOBAL WARMING (Ad-Hoc Structure)



Annex IV

National Energy Balance : 1988 EFY (1995/96 GC) (Terajoules)

Fuel	Primary Energy							Secondary Energy					
	Woody Biomass	Crop Residue	Process Residue	Bagasse	Dung	Hydro	Crude Oil	Biogas	Briquette	Charcoal	Electricity	Refinery Gas	LPG
	14.5 MJ/kg	15.5 MJ/kg	14.5 MJ/kg	10 MJ/kg	13.8 MJ/kg	4.23 MJ/kg	42.558 MJ/kg	18.9 MJ/CUM	14.5 MJ/kg	29 MJ/kg	3.6 MJ/KWh	46 MJ/Kg	45.25 MJ/Lit
GROSS SUPPLY	644,037.44	222,864.44	3,196.33	4,577.49	425,242.02	6,384.52	27,793.35	0	0	0	0		8.55
Production	644,037.44	222,864.44	3,196.33	4,577.49	425,242.02	6,384.52							
Import							27,796.35						8.55
Stock change													
INPUTS TO CONVERSION	29,494.93	9.85	9.85	0	3.95	6,384.52	27,796.35	0	0	0	0	0	0
Pertoleum Refining							27,796.35						
Charcoal Production	29,494.93												
Electricity Gereration (EELPA)						6,384.52							
Electriciity Generation (Non-EELPA)						0							
Biogas					3.95								
Briquette		9.85	9.85										
OUT PUUT FROM CONVERION	0	0	0	0	0	0	0	1.13	18.72	6,783.83	5,628.29	0	260.15
Refinery Fuel													260.15
Thermal											201.46		
Hydro											5,426.84		
LOSSES FROM CONVERSION	22,711.09	0.49	0.49		2.82	957.68	5,491						
TRANSMISSION AND DISTRIBUTION LOSSES											1,021.69		
TRANSFER													
EXPORTS													
FERTILIZER		58,338.49			314,284.63								
OTHER AND NON-ENERGY USE	59,829.95	109,156.46	3,186.48	0	49,008.20	0	0	0	0	0	0		
Cattle Feed		82,307.02											
Construction	59,829.95	26,849.44			49,008.20								
Others			3,186.48										
Net Supply	**554,712.32**	**55,359.63**	**0**	**4,577.49**	**61,194,523**	**0**	**0**	**1.13**	**18.72**	**6,783.83**	**4,606.61**	**0**	**268.71**
Statistical Difference	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**56.53**
FINAL CONSUMPTION	**554,712.32**	**55,359.63**	**0**	**4,577.49**	**61,945.23**	**0**	**0**	**1.13**	**18.72**	**6,783.83**	**4,606.61**	**0**	**212.18**
Household	**516,918.60**	**52,911.08**	**0**	**0**	**59,291.53**			**1.13**	**0**	**6,571.85**	**2,020.44**	**0**	**166.59**
Urban	23,576.90	2,872.59			3,589.85			0.23		3,969.55	2,020.44		166.59

Rural	493,341.70	50,038.49			55,701.68					2,602.30			0
Agriculture	**0**	**0**	**0**	**0**	**0**				**0**	**0**	**0**		**0.13**
Transport	**0**	**0**	**0**	**0**	**0**				**0**	**0**	**0**	**0**	**0**
Road													
Rail													
Air													
Marine													
Industry	**16,432.44**	**1,415.06**	**0**	**4,577.49**	**1,517.81**			**0**	**0**	**108.78**	**1,975.72**	**0**	**37.34**
Medium & Large	992.69			4,577.49							1,963.86		35.66
Small	192.58										2.12		1.68
Cottage	15,247.17	1,415.17	1,415.06		1,517.81					108.78	9.75		
Mining													
Construction													
Grain Milling													
Services & Others	**21,361.29**	**1,033.49**	**0**	**0**	**1,135.89**			**0**	**18.72**	**103.21**	**610.44**	**0**	**8.12**
Government											3.68		0.54
Commercial	21,361.29	1,033.49			1,135.89				18.72	103.21	580.44		7.08
Other											26.32		0.49

NATIONAL ENERGY BALANCE 1995/96 Continued

Fuel	Secondary Energy									
	Gasoline	Avgs	Jel Fuel	Kerosene	Disel Oil	Fuel Oil	Sub Sub total Biomass Fuels	Sub Sub total Petroleum Fuel	ASPHALT	Total
	32.1	31	34.6	35.3	36.3	38.6				
	Mj/Lit	MJ/Lit	MJ/Lit	MJ/Lit	MJ/Lit	MJ/Lit				
GROSS SUPPLY	2,419.73	5,953.95	0	0	12,213.06	0	1,299,917.48	48,388.65	0	1,382,484.00
Production							1,299,917.48	0		1,306,302.00
Import	2,419.73	5,953.95			12,213.06		0	48,388.65		76,182.01
Stock Change							0	0		0
INPUTS TO CONVERSION	0	0	0	0	686.08	0	29,518.58	28,479.43	0	97,804.17
Production Refining				0			0	27,793.35		55,586.71
Charcoal Production							29,494.93	0		29,494.93
Electriciiity Generation (EELPA)					464.85		0	464.85		12,276.21
Electricity Generation (Non-EELPA)					221.22		0	221.22		422.68
Biogas							3.95	0		3.95

Briquette							19.7	0		19.7
OUTPUTS FROM CONVERION	2,646.42	0	0	1,589.52	6,737.82	11,068.63	6,803.68	22,302.55	0	34,734.52
Refinery Fuel	2,646.42	0		1,589.52	6,737.82	11,068.63	0	0		22,302.55
Thermal							0	0		201.46
Hydro							0	5,975.42		5,426.84
LOSS FROM CONVERSION					484.62		22,714.90	0		35,138.80
TRANSMISSION AND IDSTRIBUTION LOSSES							0	0		1,021.69
Transfer							0	0		0
EXPORTS							0	0		0
FERTILIZER							372623.13	0		372,623.13
OTHER & NON-ENERGY USE	0	0	0	0	0	0	221,181.10	0	0	221,181.10
Cattle Feed							82,307.02	0		82,307.02
Construction							135,687.60	0		135,687.60
OTHER							3,186.48			3,186.48
NET SUPPLY	**5,066.15**	**5,953.95**	**0**	**1,589.52**	**18,264.81**	**11,068.63**	**683,398.36**	**36,236.35**	**0**	**724,241.31**
Statistical Difference	**-852.38**	**5,947.88**	**-1,864.49**	**-5,460.45**	**2,231.69**	**7,288.18**	**0**	**1,371.53**	**0**	**1,371.53**
FINAL CONSUMPTION	**5,918.53**	**6.08**	**1,864.49**	**7,049.97**	**16,033.12**	**3,780.45**	**683,398.36**	**34,864.82**	**0**	**722,869.79**
Household	0	0	0	6,579.13	288.7	0	635,694.19	7,034.43	0	644,749.06
Urban				6,250.17	118.37		34,009.12	6,535.14		42,564.70
Rural				328.96	170.33		601,685.07	499.29		602,184.36
Agriculture	**0**	**0**	**0**	**0.04**	**816.28**	**0**	**0**	**816.44**		**816.44**
Transport	**5,918.53**		**1,637.48**	**0**	**10,356.78**	**0**	**0**	**17,918.03**	**0**	**17,918.03**
Road	5,918.53				10,260.59		0	16,179.12		16,179.12
Rail					96.2		0	96.2		96.2
Air		5.24	1,637.48				0	1,642.72		1,642.72
Marine						0	0	0		0
Industry	**0**	**0**	**0**	**91.69**	**3,396.22**	**3,766.63**	**24,051.58**	**7,291.88**	**0**	**33,319.19**
Medium & Large		0	0	68.48	516.19	3,735.71	5,570.18	4,356.03		11,890.06
Small				4.22	2.03		192.58	7.94		202.64
Cottage				12.46	7.78		18,288.82	20.24		18,318.81
Mining			0	0	155.07	28.87	0	183.95		183.95
Construction		0		6.53	1,962.05	2.05	0	1,970.63		1,970.63
Grain Milling					753.1		0	753.1		753.1
Services & Others	**0**	**0.84**	**227.01**	**379.12**	**1,175.14**	**13.82**	**23,652.59**	**1,271.94**	**0**	**26,067.07**
Government		0.59	226.6	11.26	1,026.86	6.1	0	336.67		1,275.63
Commercial				329.59			23,552.59	195.42		24,569.70
Other		0.25	0.42	38.27	148.29	7.72	0			221.74

Source: Ethiopian Rural Energy Promotion Center