THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER RESOURCES

NATIONAL METEOROLOGICAL AGENCY

CLIMATE CHANGE TECHNOLOGY NEEDS ASSESSMENT REPORT OF ETHIOPIA

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ADDIS ABABA

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THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
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Editor: Abebe Tadege

This report is the output of a project entitled "Climate Change Enabling Activities -Phase II" that was supported by the GEF through the UNDP.

JUNE 2007
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Cover page:

The pictures shown on the cover page represent a natural forest found in south-west Ethiopia, Bonga area (photo credited to Dr Deribe Gurmu, Forestry Research Center), improved stove that is being promoted in Ethiopia for better energy efficiency, solar panels, the Gilgel Gibe hydro dam and wind mills (source: Ethiopian Rural Energy Development and Promotion Center).

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FOREWORD

Achieving the ultimate objective of the United Nations Framewok Convention on Climate Change (UNFCCC) requires technological innovation and rapid and widespread transfer and deployment of Enivironmentaly Sound Technologies (EST). Article 4.5 of the UNFCCC commits developed country parties (also known as Annex I parties) to take steps in providing support for developing country parties (also known as non-Annex I parties) in the process of technology transfer. A very important stage of work in the process of technology transfer is Technology Needs Assessment (TNA). In light of this, the Conference of the Parties of the UNFCCC by its Decision 4/CP.4 urged non-Annex I parties to submit their priority technology needs for mitigation and adaptation.

In this prilimnary report, effort was made to identify potential technologies that Ethiopia may need to adopt to contribute towards the objective of the Convention and to her own sustainable development goals. The report indicates the existance of many potential areas for intervention to reduce greenhoue gas emissions in the country including Energy, Agriculture, Land use change and forestry and Waste sectors. It is known that Ethiopia is endowed with rich natural resource in terms of renewable energies namely, hydropower, geothermal, wind, solar, and biomass. However, the exploitation of these natural resources is a major challenge which needs to be met through technology transfer, financial suport and capacity building. In this regard, it is hoped that all concerned bodies including Annex I parties will take a leading and proactive role in meeting the challenges of climate change.

The Government of Ethiopia would like to thank the Global Environmental Facility and UNDP for their financial support. The National Meteorological Agency deserves special gratitude for its tremendous effort in coordinating the Climate Change Enabling Activites-Phase II project, which led to the preparation of this Report.

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NMA is also very grateful to the Climate Change Project Steering Committee members and their respective institutions for their support in guiding the project. Furthermore, NMA wishes to express its sincere appreciation to the B and M Development Consultants PLC for preparing the technical reports which served as input for synthesizing this report.

Appreciation also goes to the project managmnt team members namely Mr. Abebe Tadege, Dr. Abebe Yesahnew, Mr. Million Bekele, Mr. Habtu G/Yohannes, Mrs Aklile Assefa, Mrs. Kidist Endashaw and Mrs Sada Abdulwasie for their relentless efforts to carry out the day to day activites of the Project.

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and National Focal Point to the UNFCCC

ABBREVIATIONS AND ACRONYMS

AAHB	Addis Ababa Health Bureau
AAWSA	Addis Ababa Water and Sewerage Authority
ADLI	Agricultural Development Led Industrialization
BOD	Biochemical Oxygen Demand
BACT	Best Available Control Technology
C	Carbon
C/C	Clinker/Cement ratio
$Ca(OH)_2$	Calcium hydroxide
$CaCO_3$	Calcium carbonate
C_2F_6	Hexafluoroehtylene
CCS	Carbon Capturing System
CDM	Clean Development Mechanism
CF_4	Carbon tetra-fluoride
CFCs	Chlorofluorocarbons
CH_4	Methane
CKD	Cement Kiln Dust
CO_2	Carbon Dioxide
COP	Conference of Parties
CRDA	Christian Relief and Development Association
CSA	Central Statistical Agency
CSE	Conservation Strategy of Ethiopia
DDMI	Digestible Dry Matter Intake
DM	Dry Matter
DZARC	Debre Zeit Agricultural Research Center
EEA	Ethiopian Electric Agency
EEPCO	Ethiopian Electric Power Corporation
EFAP	Ethiopian Forestry Action Program
EIAR	Ethiopian Institute of Agricultural Research
ENEC	Ethiopian National Energy Committee
EP	Electrostatic Precipitator
EPA	Environmental Protection Authority

EREDPC	Ethiopian Rural Energy Development and Promotion Center
ESTs	Environmentally Sound Technologies
ESTA	Ethiopian Science and Technology Agency
EWCO	Ethiopian Wildlife Conservation Organization
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
Gg	Giga gram (1 million gram; 1000 kg, or 1 tone)
GHG	Greenhouse gases
Gt	Giga tone
HCFC's	Hydrochlorofluorocarbnos
HCl	Hydrogen chloride
HCN	Hydrogen cyanide
HF	Hydrodgen fluoride
HFC's	Hydrofluorocarbons
IBC	Institute of Biodiversity Conservation
ICS	Interconnected system
ILRI	International Livestock Research Institute
INCD	International Network for Cultural Diversity
INCE	Initial National Communication of Ethiopia (i.e. to the UNFCCC)
IPCC	Intergovernmental Panel on Climate Change
ISWM	Integrated Solid Waste Management
LED	Light Emitting Diode
M^3/cap/yr	Cubic meter per capita per year
MEDAC	Ministry of Economic Development and Cooperation
MJ	Mega joules
Mm^3/yr	Million Cubic Meter per year
MoA	Ministry of Agriculture (former name)
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resources
MPMF	Montreal Protocol Multilateral Fund
MSW	Municipal Solid Waste
Mt	Metric tone
N_2	Dinitrogen

N_2O	Nitrous Oxide
NaOH	Sodium hydroxide
NFPAs	National Forest Priority Areas
NGOs	Non-Governmental Organizations
NH_3X	Ammonia compound
NH_3	Ammonia
NH4-	Ammonium ion
NMSA	National Meteorological Services Agency
NMA	National Meteorological Agency
NO	Nitric oxide
NOX	Oxides of nitrogen
NOx	Nitrogen oxides
PAH's	Polycyclic aromatic hydrocarbons
PFC	Perfluorocarbon
PFE	Pastoralist Forum of Ethiopia
PM	Particulate Matter
PRSP	Poverty Reduction Strategy Paper
RET	Renewable Energy Technologies
RFPAs	Regional Forest Priority Areas
SCM	Supplementary Cementing Material
SCR	Selective Catalytic Reduction
SCS	Self Contained System
SDPRP	Sustainable Development and Poverty Reduction Plan
SEC	Specific Electric Consumption
SF_6	Sulfur hexafluoride
SIC	Soil Inorganic Carbon
SO_2	Sulfur dioxide
SOC	Soil Organic Carbon
SRES	Special report on emission scenario
SWDS	Solid Waste Disposal Site
TJ	Tera Joules = 10^{12} Joules
TNA	Technology Needs Assessment
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program

UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United National Industrial Development Organization
UNSO	United Nations Sahlian Office
VFA	Volatile fatty acids
VS	Volatile solids

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EXECUTIVE SUMMARY

The United Nations Framework Convention on Climate Change (UNFCCC) very well recognizes the importance of technology transfer as a key means to combat man-made climate change. This is clearly stated in Article 4.5 of the Convention. The Fourth Conference of Parties (COP-4) by its Decision 4/CP.4 also urged Non-Annex I Parties to submit their priority technology needs for mitigation and adaptation.

This Report is the output of a project entitled "Climate Change Enabling Activities -Phase II" which had been going on from 2005 to June 2007 with a financial support of the GEF through the UNDP. The project was implemented by the National Meteorological Agency in collaboration with governmental and non-governmental organizations.

The project had the following objectives:

- Assessing, identifying and submitting technology needs for mitigation to the COP of the UNFCCC based on national development needs and priorities
- Enhancing public awareness on climate change and
- Capacity building in priority areas

The approach adopted in preparing the technology needs assesment was generally following the guidelines prepared by the UNDP and Climate Technology Intiatives (CTI). Besides, review of related litratures and consultations with stakeholders were also undertaken.

Two stakeholder workshops were orgnaized at the national level. The first workshop was held on 17 November 2005 with the objective of scoping and sensetizing stakeholders about the project. The second workshop was held on 03 November 2006 to discuss the draft final document on TNA. About 200 experts drawn from governmental organizations, academia, the private sector and NGOs paricipated in these workshops.

The Report is divided into five chapters covering an introduction, an overview of Ethiopia's greenhouse gas emmisions, potential technology options, barriers for technology transfer and priotrized technologies. Project profiles/concepts that can be further elaborated into detailed project proposals are also annnexed to the Report. The titles the project profiles is summarized in Table 1.

The assessment was done based on the IPCC greenhouse gas emission categories/sectors namely; Energy, Agriculture, Land use change and forestry, Industrial processes and Waste. Sub-sectors were also selected under each sector based on the relative magnitude of GHG emission levels. According to the Initial National Communication of Ethiopia to the UNFCCC, GHG emissions in Ethiopia totaled about 48,003 Gg CO_2-equivalents in 1994, excluding CO_2 emissions/removals in the Land use Change and Forestry sector. Sector-wise Ethiopia's GHG emission profile is dominated by emissions from Agriculture contributing 80% of the total while gas-wise it is dominated by CH_4 contributing 80% of the total CO_2 -equivalent emissions in 1994.

The Technology Needs Assessment process passed through the following steps:

- Identification of priority sectors,
- Compilation of technology information,
- Setting criteria for prioritization,
- Identification of barriers for technology transfer and
- Selection of technologies based on the criteria

Criteria used for prioritization include;

- Development benefits of the technology in terms of value added and the improvement of the quality of life for the majority of the population,
- Market potential of the technology in terms of attracting investment and being in demand,
- Potential of the technology to reduce greenhouse gas emissions,
- Potential to build on existing/on-going national programs that are already receiving government support and
- Cost

A number of barriers for technology transfer were identified in each sector. The most common barriers cited in all sectors were:

- Lack of financial resources,

- Lack of technical capacity,
- Lack of awareness and
- Lack of adequate coordination, institutional set up and clear policies/mandates.

Technologies and interventions that were identified and prioritized for GHG reduction in the five sectors are presented below.

1. Priority Technologies for the Energy Sector

1.1 Power Generation

- Generation and wider use of electricity from hydro-power including exporting to neighboring countries
- Micro-pico hydropower generation
- Photovoltaic
- Geothermal
- Wind turbine

1.2 Industry

- Conservation of energy through efficiency and management improvement
- Switching energy sources

1.3 Transport

- Alternative fuel
- Alternative means of transport
- Compact vehicles
- Efficient vehicles
- Infrastructure and systems improvement

1.4 Household

- Fuel switching
- Stove efficiency improvement

2. Priority Technologies for the Agriculture Sector

Several potential technology options from relevant sources were reviewed and promising technologies were short-listed. Further review and prioritization by stakeholders on the basis of selected criteria resulted in the identification of six technologies. Project profiles/concept notes were prepared for these technologies. Barriers for the implementation of the technologies and the means to overcome them were also assessed.

Technologies/interventions/practices for reducing the emission of methane from grazing livestock include

- Reducing livestock numbers by improving productivity
- Increasing the efficiency of animal production,
- Genetic improvement
- Manipulation of the rumen microbial ecosystem
- Feed additives and
- Improvement of farm management.

Technologies and practices for reducing N_2O include

- Optimization of soil aeration and water status through irrigation and drainage
- Improved management of fertilizer application, amount, types and methods and time of application, soil PH adjusted by application of lime, supply of organic matter, and compaction of soil by animals and farm machinery.

3. Priority Technologies for Land Use Change and Forestry Sector

Forest related interventions that were proposed for the reduction of GHGs are

- Improved management of existing forests
- Expansion of forest cover and
- Sustainable use of wood fuels as a substitute for fossil fuels.

4. Priority Technologies for Industrial Process Sector

The main emission in this sector originates from the production of cement. A number of mitigation options were identified for this sector. These options include

- Raw material conservation
- Efficient use of end products
- Material recycling
- Technology improvement and
- Demand reduction.

5. Priority Technologies for the Waste Sector

- Composting
- Sanitary landfill and
- Integrated solid waste management

Recommendations

This Report is not exhaustive. Further studies and assessments need to be done to update the Report and come up with a clear picture of the technological needs of the country. The following points are recommended when using this report.

- Many of the technologies/interventions identified may need to be further tested through feasibility studies.
- Technology needs will change through time, Hence technology need assessment needs to be carried out regularly.
- Stakeholders' active participation and cooperation needs to be ensured in the technology transfer process.
- The technical reports, prepared by national consultants on each of the five sectors which are available at NMA, need to be referred for more detailed information.

Table 1: Summary of project titles whose project profiles/ concepts annexed in climate change Technology Needs Assessment (TNA) report of Ethiopia

no	Project title
1	**Energy sector**
	Power Generation sub-sector
1.1	Gilgelgibe III Hydropower Plant for Exporting Electricity
1.2	Establishment of Micro and Pico Hydro power plants
1.3	Off-Grid Solar Electrification
	Transport Sub-sector
1.4	Biodiesel Production
1.5	Gasoline - Ethanol Blending
	Industry sub-sector
1.6	Energy Efficiency Improvement
	Household sub-sector
1.7	Use of Gel and Modified Liquid from Ethanol
1.8	Dissemination of Improved Stoves
2	**Agriculture sector**
2.1	Urea treatment of fibrous feeds (crop residues and native hay) to enhance feed intake and digestibility.
2.2	Use of Urea-molasses multi-nutrient block as supplement to fibrous feed to enhance feed intake and digestibility
2.3	Introduction of high quality fodder legumes in cereal crop rotations for strategic supplementation of crop residue-based diets, and soil nutrient accretion.
2.4	Expansion of sugarcane plantations in irrigable land resources of Ethiopia.
2.5	Promotion of conservation tillage practice in high erosion-prone environments based on rotations of high-value crops (‘noug’, G. Abyssinia) with fodder legumes
2.6	Development of Silvopastoral plantations in hydromorphic and halophytic environments of Ethiopia.
3	**Land Use Change and Forestry sector**
3.1	Conservation of High Forest and Woodland Vegetation of Ethiopia
3.2	Woodland Conservation/Management
3.3	Forestation
3.4	Substitute Management
4	**Industrial Process sector**
4.1	Intensification of plant growth in the premise of industries
4.2	Use of additional raw material (blending)
4.3	Carbon dioxide capture and storage
5	**Waste sector**
5.1	Solid Waste Composting and Sanitary Land fill

Chapter 1
INTRODUCTION

1.1 Project Background

Global climate change is one of the serious environmental problems facing mankind today. The cause for anthropogenic climate change is the accumulation of greenhouse gases in the atmosphere, which originates from various human activities. The production and use of energy from fossil fuels is by far the largest source of greenhouse gases.

The Fourth Assessment Report of the IPCC (IPCC, 2007) asserts with evidence that most of the global warming that has occurred over the last 50 years is attributable to human activities. The report further indicates that global temperature increase is likely to trigger serious consequences for humanity and other living things, including a rise in sea levels, and a greater frequency and severity of extreme weather events.

The ultimate objective of the UNFCCC is stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Article 4.5 of the Convention states that developed country Parties "shall take all practicable steps to promote, facilitate, and finance, as appropriate the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly developing country Parties, to enable them to implement the provisions of the Convention". Based on the request made by the Parties to the UNFCCC at the Fourth Conference of the Parties (COP-4), the UNFCCC Secretariat conducted a consultative process to help identify and define key elements of a framework for technology transfer under the UNFCCC. In addition to Article 4.5 of the Convention, which deals with technology transfer, Article 4.7 also alludes to the dependence of developing countries for financial support and technology transfer to enable them to effectively implement their obligations under the Convention. Decision 4/CP.7 adopted a Framework for meaningful and effective actions to enhance the implementation of Article 4.5 as well as established an expert Group on Technology Transfer. The framework for technology transfer consists of five components.

Technology needs assessment is one of the components of an integrated set of activities that are designed to enhance technology transfer.

Recognizing that the critical first step to facilitating technology transfer involves identification and communication of prioritized technology needs, the COP requested the GEF to help Parties "identify and submit to the Conference of the Parties their prioritized technology needs, especially as concerns key technologies needed in particular sectors of their national economies conducive to addressing climate change and minimizing its adverse effects". The GEF responded to this request by providing assistance through additional financing for capacity building in priority areas (Phase II top ups) of up to $US 100,000 per country.

Despite its small GHG emissions, Ethiopia, as a Party to the Climate Convention, is expected to contribute in meeting the objectives of the Convention. Phase I of the project on climate change enabling activities was finalized through the submission of the Initial National Communication of Ethiopia to the UNFCCC on 16 October 2001. As a continuation to the work identified in the National Communications to the UNFCCC and in response to a request from the Conference of the Parties to the UNFCCC to help countries identify and submit their prioritized technology needs, the GEF has made available through the UNDP, additional financing for capacity building in priority areas, including technology transfer. In line with this context, the project was approved by the government of Ethiopia with the following objectives;

- Assessing, identifying and finally submitting technology needs for mitigation to the COP of the UNFCCC based on national development needs and priorities
- Enhancing public awareness on climate change
- Capacity building in priority areas

The project was implemented by the National Meteorological Agency in collaboration with governmental and non-governmental organizations in the period from 2005 to June 2007.

This Report is a synthesis of five technical reports, which were prepared on sectoral basis by national consultants. Interested individuals are advised to refer to these reports which are available

at NMA for detailed information. Although efforts were made to address priority climate change mitigation technology needs of Ethiopia in this report, it is by no means an exhaustive and complete one. Rather, the report should be seen as a preliminary source of information, which gives a broad and general indication of the priority areas for climate change mitigation technologies of the country. Further more, the report needs to be updated as more studies and assessments are conducted in the future.

The report has five chapters covering an introduction, an overview of Ethiopia's greenhouse gas emmisions, potential technologies, criterias for technology selection, barriers for technology transfer and priotrized technologies. A number of project concepts that can be further elaborated into detailed project proposals are also annexed to the report.

1.2 Approach to the Needs Assessment

As TNA needs to be country driven, the report was prepared through a consultative process that engaged relevant stakeholders. The exercise was guided by the procedures specified in the following documents;

- UNDP/GEF Handbook on Methodologies for Technology Needs Assessment, final draft, UNDP, January 2003
- Special Report on Methodological and Technological Issues in Technology Transfer, IPCC, January 2000
- Initial National Communication of Ethiopia (INCE) to the UNFCCC, NMSA, June 2001
- Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities, Developing and Transition Country Approaches and Experiences, Climate Technology Initiative (CTI), March 2002.

The experiences of other countries and relevant national and sectoral policies, regulations, programs and projects were also reviewed. Furthermore, individual consultations were carried out with officials of relevant institutions and technical personnel both from the government and NGOs. Scientific literature from relevant websites particularly that of the UNFCCC, IPCC, etc were browsed and utilized. The following activities were also undertaken.

- Various meetings were conducted to introduce the purpose of the project and to create initial awareness among stakeholders.
- A core team was established to review technical reports.
- Assessment of existing methodologies for technology needs assessment including the methodology developed by CTI and the experiences of other developing countries was conducted.
- Terms of references (TORs) were developed and national consultants identified for preparing technical reports.
- Pertinent governmental and non-governmental organizations were consulted in assessing existing technologies that could help to mitigate GHG emissions.
- A preliminary assessment of the status of the five sectors selected was carried out based on sources from the national communication, national and sectoral development plans, sectoral policies, programs and projects.
- Identification and prioritization of technologies was conducted with the assistance of stakeholders.
- Common barriers to technology transfer were identified.

1.2.1 Review of Literature

As a first step in the TNA process, a preliminary inventory of available technology options were compiled in order to use them as introductory material in the subsequent consultative process that engaged relevant stakeholders.

1.2.2 Stakeholders Consultation Process

The technology needs assessment was agreed to be country driven whereby local concerns of relevant stakeholders were assessed through consultations. The stakeholders consulted were:-

A. Research institutions (national/international)
    - Ethiopian Institute of Agricultural Research (EIAR)
    - International Livestock Research Institutes (ILRI)

B. Non-Governmental Organizations (NGOs)

- Christian Relief and Development Association (CRDA)

C. National Institutions/Ministries

- Ethiopian Science and Technology Agency (ESTA)
- Ministry of Finance and Economic Development (MoFED)
- Ministry of Agriculture and Rural Development (MoARD)
- Ministry of Water Resources (MoWR)
- Ministry of Mines and Energy (MoME)
- Ministry of Transport and Communications
- Ethiopian Rural Energy Development and Promotion Center
- Ethiopian Electric Power Corporation (EEPCO)
- Environmental Protection Authority (EPA)
- Pastoralist Forum of Ethiopia
- Addis Ababa Health Bureau
- Addis Ababa Water and Sewerage Authority
- The Private Sector

Two stakeholder workshops were orgnaized at the national level. The first workshop was held on 17 November 2005 with the objective of scoping and sensetizing about the project. The second workshop was held on 03 November 2006 to discuss the final draft document on TNA. About 200 experts drawn from governmental organizations, academia, private and NGOs paricipated in these workshops. Some pictures from the consultation workshops are shown on the back cover of this report.

Chapter 2

AN OVERVIEW OF GREENHOUSE GAS EMISSIONS IN ETHIOPIA

Greenhouse gas emission sources and sinks in Ethiopia had been documented in the Initial National Communication of Ethiopia to the UNFCCC submitted to the Convention Secretariat in 2001 (NMSA, 2001). Reference was made to this document to have an overview of GHG emissions in Ethiopia. The national greenhouse gas (GHG) inventory of 1994, which was prepared following the 1996 IPCC guideline is presented in Table 2.1.

The major sectors considered in relation to greenhouse gas emissions and sinks are: Energy, Agriculture, Industrial processes, Land use change and forestry and Waste. A brief overview of these sectors in relation to their greenhouse gas emissions is given below.

2.1 Energy Sector Emissions

Globally the energy sector is the biggest contributor to the emission of GHGs. The major emission sub-sectors considered under Energy are the electric power, industrial heat process, transport and household. The main process responsible for the production of GHGs in the energy sector is fuel combustion. In Ethiopia, among the sub-sectors that use petroleum products, transport has been identified as the biggest contributor to GHG emission followed by the construction sector. Biomass is used for domestic cooking in rural areas that account for 85 % of the population. Petroleum products are used for transport/construction, domestic cooking, and lighting, manufacturing industries and electrical power generation. In terms of fuel types used, diesel oil and kerosene contribute the largest share of GHGs emissions in the transport, construction and household sector respectively. In 1994 the total emission from the use of petroleum products in the energy sector was estimated at 2282 Gg. Emissions from the use of petroleum products in the Energy sector and its sub-sectors for 2004 is shown in table 2.2. The share of the transport and construction sector is 68.4% followed by domestic, which is 16.1%. The total emission looks to have more than doubled in the period 1994-2004 (Table 2.1, 2.2).

Table 2.1: Long Summary Report for National Greenhouse Gas Inventories (Gg) –1994 (source: NMSA 2001)

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								
International Bunkers	**NE**							
Aviation	NE							
Marine	33							
CO_2 Emissions from Biomass	**66,757**							

NE: Not Estimated

Table 2.2 GHG Emissions from Petroleum Products for 2004

	Fuel Type	**Density**	**Mass Tones**	**Volume Kiloliter**	**Emission Factor Tones/ kilo liter**	**Emission** (Gg)	**%**
Electrical Power	*Diesel*	*0.85*	*85780.42*	*100918.1*	*2.68*	***270.46***	***5.7***
Industrial Process Heat	*Fuel oil*	*0.9*	*139470*	*154966.7*	*3*	***464.90***	***9.8***
Domestic Cooking & lighting Energy						***760.84***	16.1
	Kerosene	0.8	234856	293570	2.58	757.41	
	LPG		2078	2078	1.65	3.43	
Transport &Construction						***3231.96***	***68.4***
	Gasoline	0.73	176144	241293.2	2.22	535.67	
	Diesel	0.85	720918	848138.8	2.68	2273.01	
	Jet Fuel	0.8	131249	164061.3	2.58	423.28	
	Total					**4728.16**	

2.2 Agriculture Sector Emissions

Based on the inventory of GHGs emissions done for Ethiopia, the agricultural sector accounted for 80% of the total CO_2 equivalent emissions, and thus the sector is the dominant one in national anthropogenic greenhouse gas emissions (NMSA, 2001). The national methane emission recorded in 1994 was 1808 Gg, (85% of the total national CH_4 emissions) mainly from enteric fermentation. Nitrous oxide emission in the same year was 24 Gg (81% of the total national NO_2 emissions) mainly as a result of fertilizer use in agricultural soils (NMSA, 2001).

Previous estimates show that GHG emission is on an increasing trend in Ethiopia (NMA, 2001). With the increasing human and livestock population, a parallel increase in the rate of emissions is also expected. Over the past decade (1994-2004) cattle population has increased by 30% imposing pressure on the limited grazing resources and increasing ruminant methane emission. Similarly, the high rate of human population growth requires a parallel increase in crop production through the use of chemical fertilizers especially nitrogen, the most limiting soil nutrient which unless cautiously

used would increase N_2O emission. GHGs emissions mainly arise from ruminant methane, manure management and field burning of agricultural residues.

About one-quarter of the methane (the second most important greenhouse gas after carbon dioxide) emissions caused by human activities comes from domesticated animals, through "enteric fermentation", a process whereby plant matter is converted by the methanogenic bacteria. Cattle, goats, sheep, camels, pigs, and horses release methane. The wastes of these and other animals also emit it. Factors that affect methane emission from animals include feed intake, diet composition, and digestibility of feeds. About one-quarter to one-third of methane emissions from animals is released when manure undergoes anaerobic decomposition by bacteria and other microbes into methane, carbon dioxide, and trace amounts of small organic molecules.

The chief source of N_2O is microbial activity on organic matter. Ammonia resulting from organic matter or fertilizers after a series of reactions (nitrification and de-nitrification) produces N_2O. So emission level of N_2O depends on the addition of nitrogen to soil in any form (organic or chemical N). Biomass burning produces nitrous oxide directly and the intermediate gases, nitric oxide and ammonia that serve as indirect sources of N_2O when deposited on soil. Nitrous oxide is emitted from livestock kept in house when the liquid manure is aerated and undergoes nitrification and de-nitrification and directly from solid manure stored outside or droppings in pastures.

2.3 Land use Change and Forestry Sector Emissions

According to Roper (2001), after burning of fossil fuels, the most important sources of greenhouse gas emissions are from activities related to land use, primarily tropical deforestation, and forest fires. Various studies have shown that carbon dioxide emissions from human activities are estimated to be 7.5 billion tones of carbon annually, of which 1.5 to 1.8 billion tones come from forest related sources. Deforestation is one of the most critical environmental problems facing developing countries today in terms of its long-term catastrophic impact on biodiversity, economic opportunities, social problems created and contribution to global climate change. The above ground biomass of tropical moist forests is often more than 175 tones of carbon per hectare and when cleared and burned, much of this carbon ends up in the atmosphere as carbon dioxide. While

emission of CO_2 from deforestation is significant, the Land Use Change and Forestry sector is a net sink in Ethiopia (see table 2.1).

2.4 Waste Sector Emissions

The waste sector in Ethiopia consists of solid waste (refuse) and liquid waste (waste water). The solid waste comprises the garbage, rubbish, street cleanings, dead animals, ashes, industrial refuse etc. The main sources of solid wastes are households, commercial establishments and street markets. The organic component of the solid waste of Addis Ababa is about 64% by weight. The combustible material constitute 21%; the non-combustible 3% and the organic fines 34%, the fines less than 10mm size 29% and the recyclable materials 13% by weight. The amount of refuse that has already been dispersed of in open-dump is estimated to be more than 6.6 million cubic meters or 2.4 million tons. Open dumping of solid waste in Addis Ababa in the last 10 years has an average yearly increment of 5.4%.

Waste water comes from domestic and industrial sources. The per capita waste water production from domestic sources in Addis Ababa, in the regions and in the whole country is estimated as 12.33 m^3 /cap/yr, 7.34 m^3/cap/yr and 7.54 m^3 /cap/yr respectively. The maximum waste water production comes from pharmaceuticals amounting to about 87.1 m^3/tones. The second largest amount of wastewater comes from textile industries with an amount of about 71.14 m^3 /tons.

The greenhouse gases emitted are methane, nitrous oxide, carbon dioxide, and nitrogen oxide. Methane emission originates from several anthropogenic sources including municipal solid waste, landfills and open dumps, waste water treatment, domesticated livestock and coal mining. The quantity and the composition of solid waste disposal sites and the depth of waste in the site influence the quantity of methane. The amount of municipal solid waste that goes daily to the final disposal sites for Addis Ababa city and other urban centers of Ethiopia has reached about 400 and 1600 tones respectively. Of the total solid waste generated in Addis Ababa, 60% of the solid waste is managed. Methane emission from municipal solid waste accounts for 62% of the total emissions of waste sector. For Addis Ababa city, open-dump accounts for 18% of the total emissions of urban centers in Ethiopia.

2.5 Industrial Processes Sector Emissions

Industrial process emissions are produced by an industrial process itself and are not a result of energy consumed during the process. In addition to the substantial by-product energy related emissions from cement production, the calcining of limestone to form clinker, generates carbon dioxide. This is a result of the chemical transformation of the limestone and not the burning of fossil fuel. They are also produced as a byproduct of various non-energy related industrial activities. The manufacture of cement, iron and steel, lime, aluminum, magnesium, adipic acid, nitric acid and semi-conductors represent the main sources of GHGs from industrial processes. Generally, the production of cement and iron/steel is the most significant source of non-combustion emission of carbon dioxide. The GHG emissions in the case of Ethiopian industries depicts that the mineral industries especially cement and lime industries are the major emitters and special attention is drawn on this specific sector. In addition to energy related GHG emissions, the industrial sector is responsible for a number of process-related GHG emissions. These are:

- Carbon dioxide from the production of lime and cement (calcinations process), steel (coke and pig-iron production), aluminum (oxidation of electrodes), hydrogen (refineries and the chemical industry) and ammonia (fertilizers and chemicals)
- CFCs, HFCs and hydrochloroflorocarbon (HCFCs) produced as solvents, aerosol propellants, refrigerants and foam expanders.
- CH_4 from miscellaneous industrial process (iron and steel, oil refining, ammonia and hydrogen)
- N_2O from nitric acid and adipic acid (nylon) production; perflourocarbons (PFCs) such as carbon tetraflouride and hexaflouroethylene from ammonium production and used in manufacturing processes of the semi-conductor industry and sulfurhexaflouride from magnesium production.

2.6 Aggregated Emissions

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 Land Use Change and Forestry (LUCF) sector over the three GHGs in terms of CO_2 equivalents using the IPCC 1995 GWP factors in a hundred years time horizon for the year 1994 are given in Table 2.3 and Figures 2.1 & 2.2.

GHG emissions in Ethiopia totaled about 48,003 Gg CO_2-equivalents in 1994, excluding CO_2 emissions/removals in the LUCF sector. 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.

Table 2.3: 1994 Emissions and Removals in Absolute Values (Gg) and Aggregated Emissions in terms of CO_2-equivalent Emissions (Gg) using the 1995 IPCC GWP Factors over a 100 years time horizon. (source: NMSA 2001)

	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 CO_2 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

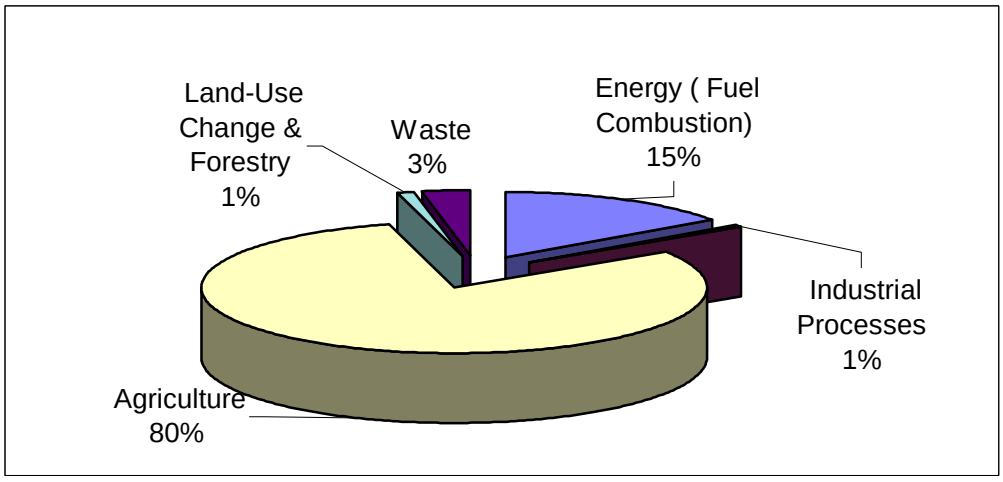

Figure 2.1: Percentage Contribution by Sector to the Total (Aggregated) GHG Emissions in CO_2 equivalent in 1994 (source: NMSA 2001)

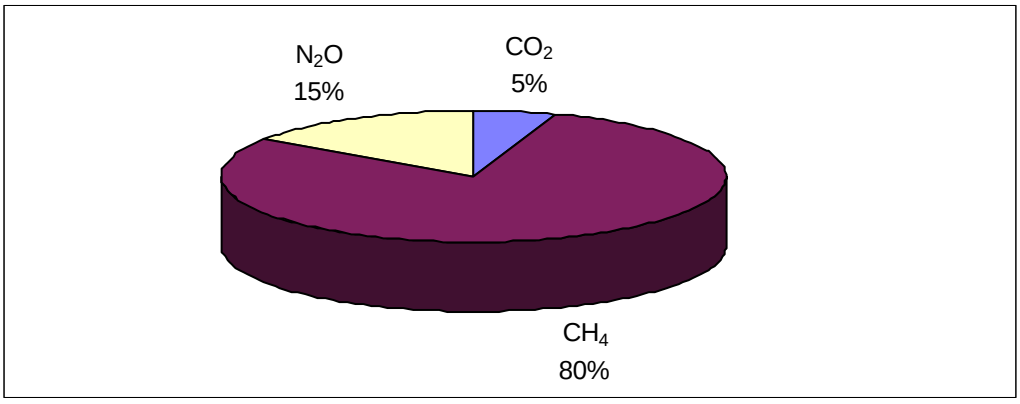

Figure 2.2: Percentage Contribution by Gas to the Total (Aggregated) GHG Emissions in terms of CO_2 equivalents in 1994 (source: NMSA 2001)

Chapter 3

IDENTIFICATION OF TECHNOLOGY OPTIONS

3.1 Technologies Identified for the Energy Sector

A number of technology options that have the potential in addressing the Climate Change problems were investigated in the Transport, Power Generation, Industry and Household sub-sectors under the Energy sector. The following section summarizes the technology options identified based on the main technical report prepared by the national consultant on the sector.

3.1.1 Technology Options for the Transport Sub-Sector

Improving the technical status of the fleet, improving traffic management through infrastructure improvement, promoting mass transportation, use of efficient and compact vehicles and switching to alternative fuels are the main technology options identified.

The cost-effectiveness of each technical option varies and depends on the availability of resources, and technology, as well as on local market conditions.

3.1.1.1 Compact Vehicles

Vehicles with 1600 cc are sufficient for Ethiopia's road condition. Thus, using highly progressive tax systems, vehicles with engine displacement volume above 1600 cc. can be discouraged for personal transportation.

3.1.1.2 Use of Efficient Vehicles

Use of modern vehicles such as cars with electronic injection systems and hybrid vehicles results in lower fuel consumption. Hybrid vehicles have very low fuel consumption. However, they might not be technically viable until the auto mechanics in the country become familiar with their maintenance. Thus, replacement of old cars in the country by new ones with better technology

including electric cars is required and limiting import of overused vehicles may have to be additional option to be looked into.

3.1.1.3 Use of Alternative Fuels

Liquefied petroleum gas (LPG) and compressed natural gas (CNG) are reported to result 10-30% GHG emission reductions per kilometer and have also less conventional emissions compared to gasoline and gas oil. The use of CNG/LPG as a fuel reduces carbon dioxide exhaust by 50 % compared to coal and 20-25 % compared to gasoline and gas oil. Carbon monoxide emissions are reduced by 70 to 90% and hydrocarbon emissions by 40 to 60% as compared to vehicles that use conventional fuel. The second method is to install a conversion kit. The conversion kit allows diesel injection to supply the fuel required to maintain idle conditions, and the gas/air mixture is designed to respond to cruise and full load power requirements. The conversion equipment generally consists of: fuel tanks, fuel lines, a pressure regulator, and a mixer to mix natural gas with incoming air.

- **Use of Bio-diesel**

A significant potential advantage of bio-diesel is that the raw materials can be produced without requiring large fossil fuel. This process produces less greenhouse gases. Though the combustion of bio-diesel leads to carbon dioxide release to the atmosphere, the quantity will not be more than what was previously extracted from the atmosphere during the growth of the crop. Thus, bio-diesel can result in substantial reduction (by about 80%) of net GHG emissions.

- **Use of Gasohol**

Gasohol is 10 % ethanol and 90 % gasoline blend (E 10). Ethiopia has a potential of producing 150 million liters of ethanol in five years after completion of the expansion of sugar factories. Gasohol can be used as fuel of spark ignition engine. The reduction in GHG emission is about 5% compared to pure gasoline. Using E10 or E15 instead of pure gasoline can result in a 10 to 15 % decrease in gasoline demand. The cost of E10 is slightly lower than gasoline.

- **Infrastructure Improvement**

Improvement of urban road transport infrastructure and efficient traffic control systems can reduce fuel consumption caused by unnecessary traffic congestions.

3.1.1.4 Alternative Means of Transportation

- **Electric Trains**

Switching freight transportation between Addis Ababa and Djibouti from trucks to electric train can cut petroleum import and GHG emissions from the commercial energy by up to 15 % while keeping freight unit price lower.

- **Promoting Use of Mass Transportation**

By increasing the bus fleets in Addis Ababa and using electric train between Addis Ababa and Nazareth, the taxi and mini-bus fleet can be reduced leading to overall reduction of fuel consumption and GHG emissions. Use of hybrid electric engines in buses will result in drastic reduction in GHG and conventional emissions.

- **Use of Non-Motorized Transport**

Use of cycles and other types of intermediate transport have to be encouraged in the different parts of the country.

3.1.2 Technology Options for the Household Sub-Sector

3.1.2.1 Fuel Switching

Use of LPG, CNG, ethanol or wood based fuels instead of kerosene for cooking, baking and boiling is proposed as an option to reduce GHG emission.

3.1.2.2 Stove Efficiency Improvement

Governmental and non-governmental organizations have made various efforts to introduce and disseminate improved stoves known as *Mirt, Gonzie* and *Lakech* in the society. Lakech utilizes

charcoal and is used for non-Injera cooking activities. It reduces charcoal consumption by up to 25 % compared to the conventional charcoal stoves made of sheet steel. Mirt is designed for baking injera. It saves energy, reduces the expenditure on fuel by one third compared to the traditional Mitad and removes smoke through a short chimney at the back.

3.1.3 Technology Options for Power Generation Sub-Sector

Reduction of electrical energy consumption for domestic purpose by the use of compact fluorescent lamps and solar water heaters so that the saved electrical energy can be made available for other activities that can replace fossil fuels. This can be achieved through the use of Photovoltaic (PV) consisting of solar home systems with white light emitting diode (wed). Hydropower use for export of electricity and use of micro and pico-hydropower for power supply of small towns and villages is suggested as an option to reduce the emission of GHGs. Exploitation of wind and geothermal energy sources are also other options.

3.2 Technology Options Identified for the Agriculture Sector

The following section summarizes the technology options identified based on the main technical report prepared by the national consultant on the sector. Technologies that are in use to mitigate anthropogenic greenhouse gas emissions from the agriculture sector can enhance crop and livestock productivity. Therefore, dual-purpose technologies are identified that enable to address the national policy of agricultural development and at the same time fulfill the country's commitment for reducing emissions of GHGs. A wide range of technology options for reducing methane emission from grazing livestock have been suggested. These include reducing livestock numbers, increasing the efficiency of animal production, genetic improvement; antimethanogenic feed additives, immunization (vaccination), manipulation of the rumen microbial ecosystem and manipulation of farm management.

Technology options identified for reducing N_2O (nitrous oxide) are, optimization of soil aeration (affected by tillage methods), water status (controlled by irrigation and drainage), fertilizer type,

amount, method and time of application, soil pH adjusted by application of lime, supply of organic matter, and compaction of soil by animals and farm machinery.

From the long list of potential technologies identified, a short list of 15 promising technologies were selected, which were further peer-reviewed and prioritized by stakeholders on the basis of five general criteria. Finally, six technologies were prioritized (out of 15 short-listed ones) in consultation with stakeholders.

3.2.1 Technology Options for Mitigation of Methane

3.2.1.1 Reduction in Livestock Number through Enhanced Productivity

This option requires farmers to reduce livestock numbers and by doing so they can reduce methane emission from enteric fermentation to the atmosphere. It will also reduce grazing pressure and halt further degradation. However, it should be accompanied with increased animal productivity. Resistance from farmers is one possible barrier for the adoption of the technology.

3.2.1.2 Increasing the Efficiency of Livestock Production

Improvement in the efficiency of conversion of feed into animal products will reduce the amount of methane emitted per unit of products.

3.2.1.3 Increasing Feed Intake

Increasing feed intake decreases the methane emission per unit of feed intake. In terms of production, studies have revealed that with increasing milk production (Kirchgessner *et al*, 1995) or live-weight gain in beef cattle (McCrabb and Hunter, 1999) an asymptotic decrease in methane emission per unit of product occurs.

3.2.1.4 Dietary Manipulation

The use of diets of higher digestibility in order to improve the nutritive value of the feed to grazing animals needs to be promoted. Decreasing dietary fiber and increasing starch and lipid can reduce methane emission.

3.2.1.5 Metabolic Efficiency

Treatment of animals with growth promoting substances to increase efficiency of production, e.g. treatment of milking cows with increasing doses of bovine somatotrophin (BST) resulted in an increase in milk production per unit intake (efficiency) and a decrease in methane emitted per kg milk (Blaxter and Clapperton, 1965).

3.2.1.6 Feed Additives

The addition of microbial feed additives improves animal productivity by directly influencing rumen fermentation. A wide range of chemicals are available including:

- Alternative hydrogen acceptors
- Halogenated methane analogues
- Antibiotics
- Defaunting agents
- Probiotics
- Bacteriocins and
- Naturally occurring plant compounds

3.2.1.7 Immunization

This technology involves vaccinating animals to ensure that methane-producing organisms are not active and thereby reducing the methane produced.

3.2.1.8 Manipulation of the Rumen Microbial Ecosystem

Microbial intervention in the rumen such as targeting methanogens with antibiotics, bacteriocins, or phage; removing protozoa from the rumen; and the development of alternative sinks for hydrogen such as reduction acetogenesis are proved to reduce methane emission.

3.2.2 Technology Options for Mitigation of Nitrous Oxide

Nitrous oxide is mainly produced in soil by the processes of nitrification and denitrification, which are controlled directly by factors such as nitrogen availability and moisture. The farmer can influence some of these factors to reduce emission. Emissions of nitrous oxide from cropped soils can be reduced through the rational use of synthetic fertilizer and manure nitrogen and the use of efficient carbon sink crops and energy cropping.

Rational Use of Synthetic Fertilizer and Manure Nitrogen

Nitrous oxide emissions can be decreased by management practices, which optimize the crop's natural ability to compete with processes whereby plant-available nitrogen is lost from the soil-plant system (i.e. ammonia volatilization, nitrification-denitrification, leaching, and run-off). If the crop uses nitrogen more efficiently or pasture, then less nitrogen will need to be supplied to meet the demand for food, less nitrogen will be lost, and less nitrous oxide will be produced. The technology options proposed are match nitrogen supply with crop demand and tighten nitrogen flow cycles through using manure. This will supply plant nitrogen and maintain plant residue on the production site. In addition, application of advanced fertilization techniques such as;

- controlled-release of fertilizers,
- placement of fertilizer below the soil surface,
- application of fertilizer to foliage,
- use of nitrification inhibitors and
- matching fertilizer type to seasonal precipitation

are also proposed.

Use of Efficient Carbon Sink Crops and Energy Cropping

The use of annual and perennial species have been identified as having high efficiency properties when converting solar energy into stored biomass which can then be converted into heat, electricity or transport fuels with zero or very low carbon emissions.

3.3 Technology Options Identified for the Land Use Change and Forestry Sector

There are three broad categories of forest related interventions for greenhouse gas mitigation. These are better management of existing forests, forest cover expansion and usage of wood fuels as a substitute for fossil fuels. The technology options and their potential to reduce GHGs are indicated in table 3.1

Table 3.1 Technology Options for Land Use Change and Forestry Sector

No.	Technology option	GHG mitigation potential
1	**Forestation** (afforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas)	Can absorb carbon dioxide from the air and store; Can be used as a substitute for fossil energy Can maintain microclimate cool and slow decomposition and release of CO_2
2	**Conservation** (Extending harvesting age, reducing or avoiding deforestation, and forest preservation)	Storage of carbon in plants Storage of carbon in the soil Slowing of decomposition and release of carbon to the air
3	**Substitute management** (Reduction of CO_2 emission from fossil fuel use through the use of biomass fuel-cultivation of perennial grasses, short rotation woody crops, or traditional crops for bio-fuels production)	To minimize use of fossil fuel and release of carbon dioxide to the atmosphere; Cheaper way of climate change mitigation

3.4 Technology Options Identified for Industrial Processes Sector

There are several mitigation options identified for industrial process emissions. The mitigation options included are raw material conservation, efficient use of end products, material recycling and technology improvement and demand reduction. The primary mitigation options focus on emissions from the cement and lime industries.

Hence the major technology options identified for carbon dioxide emission reduction are:

- industrial process energy efficiency improvement,
- material substitution (blended cement),
- carbon dioxide separation from gas and storage,
- switching to low carbon and other energy sources and
- carbon dioxide sink enhancement

3.5 Technology Options Identified for the Waste Sector

Seven technology options were assessed for the waste sector. The ranking of these options suggested that composting is the most important option followed by sanitary landfill and integrated solid waste management. The overall technology options identified are:

- composting
- sanitary land fill
- integrated solid waste management
- open dumping
- incineration
- reduction and
- waste stabilization ponds

Chapter 4

IMPLEMENTATION BARIERS FOR THE IDENTIFIED TECHNOLOGY OPTIONS

Barriers which could be technical, economic, political, cultural, social, behavioral and/or institutional exist at every stage of technology transfer process. Governments can and should play an active role in creating enabling environments that would facilitate transfer of, and access to Environmentally Sound Technologies (ESTs). Barriers that were identified in each sector are presented in the following sections.

4.1 Barriers in the Energy Sector

- Lack of awareness about energy conservation
- Lack of skill to evaluate the feasibility of energy conservation
- Lack of fund for investment in energy conservation
- Prices of technologies
- Market structure
- Institutional capacity
- Access to information
- Social and cultural behavior

4.2 Barriers in the Agriculture Sector

- The transfer of technologies is limited by the availability and cost of urea
- Scarcity of arable land and fodder seed
- Lack of responsive breed of cattle
- Poor accessibility to market
- Rigid tradition in favor of huge animal numbers
- Tribal clash
- Unpredictable climate
- Competition with food and fiber production
- High demand for sufficient labor, water and fertilizer

4.3 Barriers in the Land Use Change and Forestry Sector

- Shortage of financial capacity
- Inadequacy of trained manpower
- Absence of appropriate facilities
- Lack of clear policy provisions
- Unstable and weak institution

4.4 Barriers in the Industrial Process Sector

- Insufficient domestic infrastructure
- Lack of capital
- Lack of data to carry out cost benefit analysis
- High initial capital
- Policy barriers for technology importation
- Awareness

4.5 Barriers in the Waste Sector

- Lack of funding
- Lack of awareness on parts of decision makers, private sector and communities with methane recovery, utilization equipment and composting
- Lack of adequate space for landfill
- Unclear legal and regulatory frameworks
- Lack of capacity

Chapter 5

PRIORITY TECHNOLOGIES

5.1 Criteria Adopted for Technology Selection

As indicated in earlier chapters, five sectors were identified as major sources contributing to GHG emissions in Ethiopia. Technology options for each sector were also identified. The following criteria were used to make prioritization among the technology options identified.

- Potential for development benefits of the technology option in terms of value added and the improvement of the quality of life for the majority of the population.
- Market potential of the technology option in terms of attracting investment and being in demand
- Potential of the technology option to reduce greenhouse gas emissions as per the requirements of the Project.
- Potential to build on existing/on-going national programmes that are already receiving government support.
- Implementation barriers that can be overcome at a reasonable cost

The prioritization process involved stakeholder consultation and its results are presented below.

5.2 Priority Technologies for Energy Sector

5.2.1 Technologies for Power Generation Sub-sector

TECHNOLOGY FOR POWER GENERATION SUB-SECTOR	**RANK**
Wide use and export of electric power	1
Micro-pico hydro-electric power	2
Photovoltaic	3
Geothermal	4
Wind turbine	5

5.2.2 Technologies for the Industry Sub-sector

TECHNOLOGY FOR INDUSTRIAL SUB-SECTOR	RANK
Energy efficiency improvement	1
Energy sources switching	2

5.2.3 Technologies for the Transport Sub-sector

TECHNOLOGY FOR TRANSPORT SUB-SECTOR	RANK
Alternative fuel	1
Alternative means of transport	2
Compact vehicles	3
Efficient vehicles	4
Infrastructure and system improvement	5

5.2.4 Technologies for the Household Sub-sector

TECHNOLOGY FOR HOUSEHOLD	RANK
Energy efficiency improvement	1
Fuel substitution	2

5.3 Priority Technologies for the Agriculture Sector

Technology options	Rank
Urea treatment of fibrous feeds (crop residues and native hay) to enhance feed intake and digestibility.	1
Use of urea-molasses multi-nutrient block as supplement to fibrous feed to enhance feed intake and digestibility.	2
Introduction of high quality fodder legume crops in cereal crop rotations for soil nutrient accretion and as strategic supplements to crop residue-based diets.	3
Expansion of sugarcane plantations in irrigable land resources of Ethiopia as source of sugar, bio-fuel, feed (molasses), and CO_2 sequestration.	4
Promotion of conservation tillage practice in high erosion-prone environments based on rotations of high-value crops (‘noug’, *G. abbyssinica*) with fodder legumes.	5
Development of Silvopastoral plantations based on high biomass MPT crops in hydromorphic and/or halophytic environments in the pastoral sub-sector.	6

5.4 Priority Technologies for Land Use Change and Forestry Sector

No.	Technology option	GHG mitigation potential
1	**Forestation** (afforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas)	♦ Can absorb carbon dioxide from the air and store; ♦ Can be used as a substitute for fossil energy ♦ Can maintain microclimate cool and slow decomposition and release of CO_2
2	**Conservation** (Extending harvesting age, reducing or avoiding deforestation, and forest preservation)	♦ Storage of carbon in plants ♦ Storage of carbon in the soil ♦ Slowing of decomposition and release of carbon to the air
3	**Substitute management** (Reduction of CO_2 emission from fossil fuel use through the use of biomass fuel-cultivation of perennial grasses, short rotation woody crops, or traditional crops for bio-fuels production)	♦ To minimize use of fossil fuel and release of carbon dioxide to the atmosphere; ♦ Cheaper way of climate change mitigation

5.5 Priority Technologies for the Industrial Processes Sector

Technologies	Rank
Carbon dioxide sink enhancement	1
Efficiency Improvement	2
Switching to low carbon and other energy sources	3

5.6 Priority Technologies for the Waste Sector

Technologies	Rank
Composting	1
Sanitary landfill	2
Waste stabilization ponds	3
Reduction	4
IWMS	5
Incineration	6
Open dumping	7

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Annex I

SUMMARY OF PROJECT PROFILES

The proposed project concepts summarized below in each of the sectors and sub-sectors are based on the technology needs assessment provided in the previous chapters. They are meant for further development and consideration. However, the list is by no means exhaustive.

1. Energy Sector

1.1 Power Generation

1.1.1	***Project Title***	Development of Gilgelgibe III/IV Hydropower Plant for in country use and exporting Electricity
	Rationale/justification	Ethiopia is endowed with huge hydo-power potential. Exploitation of this potential to her own and neighbouring countries consumption can greatly contribute to reduce GHG emissions.
	Description	
	Objectives	To construct a dam with height of 240 meters and a capacity to store 14.7 million cubic meters of water for and install hydropower plant to generate 1870 MW for exporting to electricity
	Activities	Assessment of current situation Undertake consultation of stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Improved availability of water for livestock, crop irrigation, aquaculture, energy, rural industry and domestic use
	Potential long-term outcomes	Reduction of gas oil and fuel oil consumption in Ethiopia, Djibouti, Sudan and Kenya by supplying hydro electricity.

	Implementation	
	Institutional arrangement	Ministry of Water Resources will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 2 billion Project design: USD 2 million

1.1.2	***Project Title***	Establishment of Micro and Pico Hydro power plants
	Rationale/justification	Ethiopia has great potential for hydro power production. However many areas of the country do not have access to electricity.
	Description	
	Objectives	To install micro and pico hydro power plants to supply electricity to towns and villages which are far from the national grid.
	Activities	Assessment of current situation Undertake consultation of stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Study and design reports Micro and Pico Hydro dams constructed for power production
	Potential long-term outcomes	Increased access to clean energy and reduced greenhouse gas emissions
	Implementation	
	Institutional arrangement	Ethiopian Rural Energy promotion and Development Center (EREPDC) will lead the coodination of the project, stakeholder and partners includes Regional Energy and Mining Bureaus, GTZ and other NGOs, and the private sector)
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 20 million Project design: USD 800,000

1.1.3	***Project Title***	Off-Grid Solar Electrification program in Ethiopia
	Rationale/justification	85% of the population in Ethiopia live in rural areas with limited access to modern energy. Cost is estimated with 100 Birr per Wp including accessories, lamps and installation cost
	Description	
	Objectives	To electrify rural households with solar lanterns and solar home systems (SHS) in order to replace kerosene and diesel power
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Increased number of households in rural Ethiopia will have solar lanterns and solar home systems
	Potential long-term outcomes	Availability of sustainable energy source
	Implementation	
	Institutional arrangement	Ethiopian Rural Energy promotion and Development Center (EREPDC) will lead the coordination of the project, stakeholder and partners includes Regional Energy and Mining Bureaus, GTZ and other NGOs, and the private sector)
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 6 million Project design: USD 50,000

1.2 Transport Sub-sector:

1.2.1	***Project Title***	Biodiesel Production for the transport sector
	Rationale/justification	The demand for energy is growing. The price of fossil fuels is rising. Biodiesel can be produced from crops grown for energy such as maize, soybeans, rapeseed oil palm, cassava, etc or agriculture and other forms of waste and residues. Biodiesel can be produced in a way that reduces net carbon emissions.
	Description	
	Objectives	To reduce GHG emissions from petroleum use by substituting petroleum use (gas oil or diesel oil) with biodiesl
	Activities	Assessing existing situations including enabling environment Selecting appropriate sites for biomass production Installation of biodiesel plant Development of full project proposal
	Short-term outputs	Establishment of a plant with a production capacity of 300 million liters of Biodiesl per annum.
	Potential long-term outcomes	Availability of sustainable energy supply
	Implementation	
	Institutional arrangement	Ministry of Mines and Energy will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 8 million Project design: USD 500,000

1.2.2	***Project Title***	Gasoline and Ethanol Blending
	Rationale/justification	Up to 10 % ethanol can be blended with gasoline and used in standard vehicles, where as specially made flexible –fuel vehicles can use any proportion of ethanol and gasoline. Ethanol is produced from the production of sugar as a by-product. The number of sugar factories in Ethiopia is increasing and there is an opportunity to produce ethanol tat can be mixed with gasoline.
	Description	
	Objectives	To reduces CO_2 emission from petroleum products through the use of blend gasoline with 10 % ethanol.
	Activities	Assessment of current situation Undertake consultation of stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Blended gasoline with 10 % ethanol produced and utilized for vehicular use.
	Potential long-term outcomes	Sustainable supply of fuel for the transport sector and reduced greenhouse emissions
	Implementation	
	Institutional arrangement	Ethiopian petroleum corporation will lead the coordination of the project.
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 6 million Project design: USD 100,000

1.3 Industry sub-sector

1.3.1	***Project Title***	Energy Efficiency Improvement Program
	Rationale/justification	Energy efficiency improvement is one of the means proposed in meeting the objectives of the UNFCCC. It is widely believed that there is large opportunity for energy efficiency in many sectors.
	Description	
	Objectives	To increase efficiency of energy utilization by 10 % in order to save commercial fuel oil and to reduce CO_2 emissions
	Activities	Inventory and assessment of existing situation in energy efficiency Review of polices on energy efficiency Undertake consultation with stakeholders Identification of potential and target sectors/areas Preparation of full project proposal
	Short-term outputs	Current energy efficacy levels of sectors in the country assessed Policies, strategies and recommendations for energy efficiency formulated and approved
	Potential long-term outcomes	Energy saving and greenhouse gas emission reduction
	Implementation	
	Institutional arrangement	Ethiopian Rural Energy Development and Promotion Center will lead the coordination of the project.
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 1 million Project design: USD 50,000

1.4 Household sub-sector

1.4.1	***Project Title***	Dissemination of improved stoves for rural and urban households in Ethiopia
	Rationale/justification	Most rural and urban households in Ethiopia use traditional three stone stoves which is very inefficient in energy production.
	Description	
	Objectives	To reduce deforestation rate through the dissemination of improved (efficient) charcoal stove and wood stoves and there by reduce CO_2 emission
	Activities	Assessment of current situation Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Dissemination of substantial number of improved charcoal stove and wood stoves to urban and rural households.
	Potential long-term outcomes	Energy saving and low greenhouse gas emissions
	Implementation	
	Institutional arrangement	Ethiopian Rural Energy promotion and Development Center (EREPDC) will lead the coodination of the project, stakeholder and partners includes Regional Energy and Mining Bureaus, GTZ and other NGOs, and the private sector)
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 15 million Project design: USD 500,000

1.4.2	***Project Title***	Use of Gel and Modified Liquid from Ethanol
	Rationale/justification	The household sub-sector contributes a significant percent of the CO_2 emission in Ethiopia as a result of kerosene use for various purposes. As the population of the country increases the contribution of the sub-sector to CO_2 emissions will increase unless interventions steps are taken.
	Description	
	Objectives	To manufacture modified ethanol fuel (higher viscosity and flash point) using ethanol, water and patented rehological modifier.
	Activities	Assessment of existing situations Undertaking stakeholder consultations Developing full project proposal
	Short-term outputs	Reduced CO_2 emission from reduced kerosene consumption.
	Potential long-term outcomes	Availability of the sustainable source of energy for the household sector
	Implementation	
	Institutional arrangement	Ethiopian Rural Energy Development and Promotion Center will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 5 million Project design: USD 50,000

2. Agriculture sector

2.1	***Project Title***	Urea treatment of fibrous feeds (crop residues and native hay) to enhance feed intake and digestibility
	Rationale/justification	Improving animal feed quality especially those of traditional feed staff like crop residues and poor quality hay by adding a limiting nutrient such as fermentable nitrogen can increase productivity.. Simple addition of urea can lead to considerable greater intake and additional performance. The government should issue a document about utilizing crop straw to develop livestock in the major crop-growing region.
	Description	
	Objectives	• To increase feed intake to decrease the methane emission • To increase digestibility and reduce methane emission
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Improved animal feed intake and digestibility practiced by farmers and other stakeholders
	Potential long-term outcomes	Improved livestock productivity and decreased GHGs emissions**.**
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural development will lead the coordination of the project. Farmers, pastoralists and agricultural offices at district and regional levels will be he main stakeholders. Beneficiaries of the project also include urban and pre-urban communities.
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 7 million Project design: USD 200,000

2.2	***Project Title***	Use of Urea-molasses multi-nutrient block as supplement to fibrous feed to enhance feed intake and digestibility
	Rationale/justification	Crop residues are low in protein. Protein or nitrogen supplementation may therefore be used to improve the utilisation of the residues. Molasses-urea blocks added to cereal crop residues or dry mature pastures based diets ensure animal's maintenance requirements because the blocks enhance efficient ruminal fermentation. Besides, urea treatment (ammoniation) of crop residues and poor quality hay does not only increase digestibility of animal feed and feed intake but also reduces 25-75 per cent of methane emissions per unit of animal produce-meat, milk, work, etc. (Sollod and Walters, 1992).
	Description	
	Objectives	Improve the body weight gain and body condition of livestock to market standard and reduced greenhouse gases emission.
	Activities	Assess existing situation Undertake stakeholder consultations Identification of potential and target areas Develop full project proposal
	Short-term outputs	Existing situation assessed Potential sites and areas identified and piloted
	Potential long-term outcomes	Improved productivity of livestock and reduced methane emission.
	Implementation	
	Institutional arrangement	MoARD will lead the coordination of the project. Stakeholders include farming communities and pastoralists
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 5 million Project design: USD 50,000

2.3	***Project Title***	Introduction of high quality fodder legumes in cereal crop rotations for strategic supplementation of crop residue-based diets, and soil nutrient accretion
	Rationale/justification	Application of double cropping (sequential cropping**)** where forages and food crops are raised one after the other. In the highland arable farming system, fallowing has long been a traditional practice for soil nutrient regeneration. The fallow length depends on the type and nutrient status of the soil, amount of manure, mulch and rhizobial nitrogen fixed by leguminous components of the sward. Raising pulses in rotation with cereals often prolongs the cropping phase and the usual sequence is cereal – cereal – pulse. Chickpea is one, among others, grown in rotation with cereal and oil seed crops. This cultural practice for chickpea offers an opportunity to raise food and fodder crops in one cropping season on the same land.
	Description	
	Objectives	▪ To improve cash crop and animal productivity for home and foreign market ▪ To iimprove soil fertility and thus higher crop yields. ▪ To reduce methane emission
	Activities	• Assessment of current situation • Undertake consultation with stakeholders • Identification of potential and target areas • Preparation of full project proposal
	Short-term outputs	• Quality feed production • Improve the nitrogen status of soil via N fixation • Reduce expenses for chemical fertilizers • Environmentally friendly system:- increased C reserve in soil, reduced use of N fertilizer, sequester C
	Potential long-term outcomes	Improved productivity animal and crop production
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural Development (MoRAD) will lead the coordination of the project. Farmers and pastoralists are the main stakeholder
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 5 million Project design: USD 50,000

2.4	***Project Title***	Expansion of sugarcane plantations in irrigable land resources of Ethiopia
	Rationale/justification	Ethiopia has large water and land resource for sugar cane plantations. So far this potential is not exploited very well.
	Description	
	Objectives	• To increase sugar production to meet home demand and for export. • To introduce the use of bio-fuels in transport vehicles and reduce import of fossil oil.
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	• Increased production of sugar • Ethanol production from cane, maize and other cereals to substitute fossil fuel • Liquid biofuels when substituted for fossil fuels will directly reduce CO_2 emissions. • Converting the accumulated carbon in the biofuels for energy purposes, and hence recycling it, alleviates the critical issue of maintaining the biotic carbon stocks over time as for a forest sink
	Potential long-term outcomes	Sustainable energy supply for the transport sector Economic development
	Implementation	
	Institutional arrangement	Ministry of Water Resources will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 150 million Project design: USD 800,000

2.5	***Project Title***	Promotion of conservation tillage practice in high erosion-prone environments based on rotations of high-value crops ('noug', G. Abyssinia) with fodder legumes
	Rationale/justification	Conservation tillage or Reduced or no-till farming systems, in which plant residues are retained, and soil disturbance is minimized, also referred to as, Zero-tillage, Minimum tillage. Conservation tillage is invoked as any tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water.
	Description	
	Objectives	• Reduced import of fossil fuel since it saves 60% of the tractor fuel used in tilling • Export of processed edible oil and noug cake as feed • Improve animal productivity and reduce methane emission.
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	• Conventional tillage consumes 60% of the tractor fuel used in industrialized crop production and decreases soil carbon. • Minimum and zero cultivation techniques save tractor fuel. • Reduces labor, saves time • Improves soil tilth and increases organic matter • Reduces fossil fuel emissions from tractors by making fewer trips across the field; and - Reduces the release of carbon dioxide into the atmosphere by tying up more carbon in organic matter. • Conserve soil moisture, and reduce soil erosion. Benefits need to be achieved without reducing crop yields, which is more likely under dry conditions as a result of moisture conservation. E.G. Cost of uptake in Botswana is around US$31 – 38/tC saved. • Reduced or no-till farming can encourage reduced rates of nitrogen mineralization and subsequent N loss.

	Potential long-term outcomes	Sustainable land use and sustainable agricultural production
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural Development (MoRAD) will lead the coordination of the project.
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 6 million Project design: USD 200,000

2.6	***Project Title***	Development of Silvopastoral plantations in hydromorphic and halophytic environments of Ethiopia.
	Rationale/justification	Agrosilvopastoral system is the most intensive form of land management in which land is managed concurrently for the production of agricultural and forest crops and for rearing of domestic animals.
	Description	
	Objectives	• Management of land concurrently for the production of agricultural and forest crops and for rearing of domesticated animals. • High-yielding short rotation forest crops or C4 plants with potential application in such systems are the following.
	Activities	Assessment of current situation Undertake consultation of stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	Agrosilvopastoral systems piloted in selected sites
	Potential long-term outcomes	Productive and sustainable land use management
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural Development (MoRAD) will lead the coordination of the project.
	Risks and barriers	Lack of finance , lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 3 million Project design: USD 50,000

3. Land Use Change and Forestry

3.1	***Project Title***	**Conservation of High Forest and Woodland Vegetation of Ethiopia**
	Rationale/justification	There are about 58-Forest Priority Areas (FPAs), covering about 4 million ha in the country, which are under great pressure for different uses. These forests have multiple roles, which include: environmental protection and mitigation of climate change, protection of watersheds, conservation of biodiversity, and provision of different forest goods. However, due to lack of proper management system, absence of adequate budget and appropriate policy provision, these resources are dwindling from time to time. there is an urgent need for proper interventions to conserve and sustainably use the remaining existing high forest of the country to provide services for environmental protection, conserving land and biological resources. About 60% of the high forests will be put aside for protection purposes. The protection area would include slopes steeper than 35-40 percent to control erosion and potential areas for preservation of the natural flora and fauna. The remaining 40% of the natural forests will be developed for commercial wood production under sustainable management through natural regeneration and enrichment planting with indigenous species.
	Description	
	Objectives	To conserve and develop the remaining high forest, so that they may make the maximum contribution to climate change mitigation (Carbon dioxide sequestration, watershed protection for hydroelectric power generation, biomass production, etc.), soil and water conservation, land productivity improvement of the country.
	Activities	Assessment of current situation Undertake consultation of stakeholders Identification of potential and target areas Preparation of full project proposal

	Short-term outputs	• Boundaries of all NFPAs demarcated and legally protected; • Degraded forest areas rehabilitated and natural regeneration improved; • Open areas in the natural high forests planted and forest cover increased; • Carbon sink is increased micro-climate of the areas ameliorated; • Biodiversity conservation, environmental protection improved and sustained; • All major watershed areas protected and sedimentation of hydroelectric dams and other dams minimized and their lifespan increased; • Economic contribution of forests improved; and Participation of the local communities in natural resources management ensured
	Potential long-term outcomes	Sustainable use of natural resources of the country contribution to the objective of the UNFCCC
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural Development (MoRAD) will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 10 million Project design: USD 300,000

3.2	***Project Title***	**Forestation Program in Ethiopia**
	Rationale/justification	The forest cover of the country has diminished over the years. There is an urgent need to reverse the situation for a number of reasons. Increasing forest cover contributes for protection of biodiversity, land degradation, climate and water. Forestation is afforestation on previous cropland or pasture and reforestation is establishing forest on clear felled areas.
	Description	
	Objectives	To increase carbon sequestration through increasing the forest cover of the country To promote appropriate technologies in forestation To enhance improved management of forests To strengthen the contribution of the forestry sector to economic development and job creation To contribute to environmental protection
	Activities	Assess existing situation Undertake stakeholder consultations Identify potential and target areas Development of plantations Develop full project proposal
	Short-term outputs	• Forest cover of the country increased; • Degraded lands rehabilitated and land productivity improved; • Forest products supply increased; • Carbon sink increased; • Use of cow dung, crop residues decreased and organic inputs to the soil increased and also land productivity improved; • Use of inorganic chemicals in agriculture decreased and environmental pollution minimized; • Biodiversity and environmental protection improved; • Economic contribution of the forestry sector improved; and • Benefits from forestry for the local communities, private sector and public improved.

	Potential long-term outcomes	Sustainable economic development Sustainable natural resource and environmental management
	Implementation	
	Institutional arrangement	The government, local communities and private investors
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 25 million Project design: USD 700,000

3.3	***Project Title***	**Substitute management of fossil fuel with wood fuel**
	Rationale/justification	Wood fuel is the major source of energy for most urban and rural households in Ethiopia. Commercial institutions also use wood fuel as their main source of energy. This situation has contributed for the deforestation of natural forests and land degradation.
	Description	
	Objectives	To promote sustainable biomass use by substitute use of fossil fuel and reduce the amount of CO_2 emission to the atmosphere.
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	• Use of fossil fuel minimized and emission of CO_2 reduced; • Coverage of fast growing tree and other perennial crops increased; • Biodiversity and environmental protection improved; • Low cost energy supply improved; • Pressure on high forests and woodland for energy supply minimized/reduced; and Watershed protection improved and water quality and quantity improved
	Potential long-term outcomes	Sustainable energy supply
	Implementation	
	Institutional arrangement	Ministry of Agriculture and Rural Development (MoRAD) will lead the coordination of the project.
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 5 million Project design: USD 50,000

4. Industrial process sector

4.1	***Project Title***	**Intensification of plant growth in the premise of industries**
	Rationale/justification	Plants can absorb the carbon dioxide emitted from cement industries. Intensification of plant growth in the premise of industries will reduce the amount of CO_2 in the atmosphere by many folds. Plants use CO_2, inorganic carbon, and source of energy, which is converted into organic carbon through the process of photosynthesis.
	Description	
	Objectives	To reduce carbon dioxide emission, to condition the soil, and to support the fuel sector.
	Activities	Conduct situation analysis and policy review Undertaking consultations with stake holders Development of full project proposal Planting of trees
	Short-term outputs	Forest plantations established that can compensate CO_2 emissions from cement production
	Potential long-term outcomes	Environmentally sustainable production of cement
	Implementation	
	Institutional arrangement	*Ministry of Trade and Industry will coordinate the project*
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 5 million Project design: USD 50,000

4.2	***Project Title***	Use of additional raw material (blending) for cement production
	Rationale/justification	The use of materials such as pulverized fly ash or slag to replace raw materials such as clay in cement kilns has the potential to reduce CO_2 emissions at the point of cement production, as these products use less energy than clay. A much more efficient way of using industrial by-products and natural materials is to mix these with cement clinker and grind both materials to cement. Such cement consequently consists of cement constituents other than ground clinker. The additional cement constituents often provide additional beneficial properties to the cement. The modification of the cement composition by the usage of additional cement constituents results in considerable reductions in CO_2 emissions as not only the process related CO_2 but also fuel related CO_2 is reduced but also.
	Description	
	Objectives	Blending of fly ash and the likes will cut the raw material to be calcined thus reducing the emission of carbon dioxide to the atmosphere.
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	The implementation of the option will have clear benefits the cement industry can provide in CO_2 reduction through integrating cement kilns within an overall waste management strategy, through the use of materials such as industrial by-products as additional cement constituents.
	Potential long-term outcomes	Sustainable cement production and reduced CO2 emissions
	Implementation	
	Institutional arrangement	Cement factories will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 6 million Project design: USD 150,000

4.3	***Project Title***	Development of carbon dioxide capture and storage facilities
	Rationale/justification	CO_2 capture and storage involves capturing the CO_2 arising from the combustion of fossil fuels, as in power generation, or from the preparation of fossil fuels, as in natural-gas processing. It can also be applied to the combustion of biomass-based fuels and in certain industrial processes, such as the production of hydrogen, ammonia, iron and steel, or cement. Capturing CO_2 involves separating the CO_2 from some other gases. The CO_2 must then be transported to a storage site where it will be stored away from the atmosphere for a very long time (IPCC, 2001a). In order to have a significant effect on atmospheric concentrations of CO_2, storage reservoirs would have to be large relative to annual emissions.
	Description	
	Objectives	To reduce the concentration of carbon dioxide emitted to the atmosphere to harmless level.
	Activities	Assessment of current situation Undertake consultation with stakeholders Identification of potential and target areas Preparation of full project proposal
	Short-term outputs	CO_2 capturing and storage facility established on a pilot basis
	Potential long-term outcomes	Sustainable cement production
	Implementation	
	Institutional arrangement	Cement factories
	Risks and barriers	Lack of finance, lack of capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 15 million Project design: USD 100,000

5. Waste Sector

5.1	***Project Title***	**Solid Waste Composting and Sanitary Land fill in Addis Ababa**
	Rationale/justification	The Sanitation, Beautification and Park Development Agency of Addis Ababa City Administration is in charge of collection and disposal of solid waste in the city. The solid wastes are being dumped near Reppi Area, southwest of Addis Ababa. The major technology being used for solid waste disposal is "open dumping". This has become very nuisance, highly unsanitary and is creating dangerous health hazards. There is a strong complaint by people living near and surrounding the dumping site. The solid waste of Addis Ababa is composed of putrescible and non-putrescible components. The organic component of the solid waste in Addis Ababa is about 64% by weight. The major source of organic solid waste is the main "Fruit and Vegetable Center" located south of the A.A Municipality Building. In the ranking of waste sector technologies, "Composting" has the highest ranking; and the "Sanitary Land Fill", the second highest. The Project Concept for solid wastes of Addis Ababa are put forward to make use of the ranked technologies namely "Composting" for organic solid wastes, and "Sanitary Land fill" for non-organic solid wastes. The project ideas for Addis Ababa solid wastes disposal, when implemented, can act as "sample" for disposal of solid wastes for the rest of urban centers in the country.
	Description	
	Objectives	**To utilize waste for fertilizer production** To utilize methane generated from waste for the production of energy through the development of sanitary land fill
	Activities	Assess existing situation Identification of potential sites/areas Undertake stakeholder consultations Develop full project proposal

	Short-term outputs	The sanitation condition of urban and sub-urban dwellers is improved To reduce emission of methane from waste
	Potential long-term outcomes	Improved waste management practice in urban areas
	Implementation	
	Institutional arrangement	Sanitation, Beautification and Park Development Agency of Addis Ababa City Administration will lead the coordination of the project
	Risks and barriers	Lack of finance, lack of technical capacity
	Evaluation and monitoring	A project steering committee composed of representatives from stockholders will oversee the project. Regular progress reports will be submitted to all concerned bodies by the lead institution and field visits will be conducted. as appropriate. Evaluation of the project will be carried out by independent technical experts.
	Estimated (indicative and tentative) project cost	Full project implementation: USD 10 million Project design: USD 600,000

Consultation workshops with stakeholders on Climate Change Technology Needs Assessment