DRAFT REPORT ON

KENYA'S CLIMATE CHANGE TECHNOLOGY NEEDS AND NEEDS ASSESSMENT REPORT UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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PREFACE

The report on Kenya's Technology Needs Assessment represents an important step forward in the country's continued commitment to meeting sustainable development and working with the international community in achieving the objectives of the United Nations Framework Convention on Climate Change (UNFCCC).

Kenya submitted her first National Communication to the UNFCCC in October 2002 at the Eighth Conference of the Parties held in New Delhi, India. The report covered studies carried nationally on greenhouse gases inventory, vulnerability and adaptation to climate change, programmes to address climate change and its adverse impacts including abatement and sink enhancement and building capacity to integrate climate change concerns into planning amongst other issues.

During the phase 1 of the Climate Change Enabling Activities Project, due to inadequate financial resources, it was not possible to carry out in-depth financial and/or technological needs and constraints associated with the implementation of the Convention.

Consequently the resources that were availed by the Global Environment Facility (GEF) to keep alive the climate change dialogue in countries before the onset of Second National Communications were used to this effect and the output is the technology needs and needs assessment report.

The study carried out in 2000 by the Intergovernmental Panel on Climate Change on Technology Transfer and Climate Change concluded that stabilizing concentrations of greenhouse gases in the atmosphere requires technological innovation, followed by the widespread transfer of new technologies and skills to developing countries, but also between developing countries.

The report further concluded that regardless of other factors, the atmospheric concentration of GHGs could be stabilized at an appropriate level *only* with a significant shift in the patterns of technological development and diffusion.

The work carried out toward this report on Kenya's Technology Needs Assessment is but a first step towards factoring the development and diffusion of environmentally sound technology into our investment strategies.

The Assessment was carried out through a concerted consultative process in which the experts from government, private sector and the civil society drafted, revised and ultimately approved the report that was presented to a stakeholder forum before being submitted to the Conference of the Parties to the UNFCCC.

The sectors covered are as were identified in the first national communication as having potential for GHG emissions. The study reports that there are a number of opportunities for GHG mitigation for which the country requires international assistance.

The report is not exhaustive and I would like to welcome and endorse it to a wider audience and invite feedback and comments to further improve it if it is to be a living document. Kenya has stated her objective of becoming a Newly Industrialized Country by 2020 and technology is critical in determining the achievement of this objective. Through this exercise we can contribute to the process of the preparation of regulations to facilitate technology transfer and modalities to acquire and adopt new technologies that emit less GHGs, are cost-effective and improve productivity.

The preparation of this report has contributed to capacity building in the country and we look forward to getting assistance through bilateral and multilateral and private sector sources, for the implementation of programmes that will lead to the transfer of the identified technologies so that the nation would be further empowered to pursue a sustainable development pathway.

On behalf of the Ministry of Environment, Natural Resources and Wildlife, I would like to extend my sincere gratitude to the National Focal Point who coordinated the whole exercise, the authors, reviewers, contributors and editors of the report. The Ministry would also like to thank UNEP, the GEF Implementing Agency, for the support given throughout the process of report preparation.

Nairobi …… Date: …….

Minister

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Abbreviations – Acronyms

4/CP.4	-	Decision No.4 at the 4th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)
ACP – EU	-	African Caribbean &Pacific – European Union
ADF	-	African Development Fund
AEE	-	Association of Energy Engineers
ASALs	-	Arid Semi-Arid Lands
a-Si	-	Amorphous silicon
BAT	-	Best Available Techniques
BEP	-	Best Environmental Practices
BioCF	-	Bio Carbon Fund
CBD	-	Convention on Biological Diversity
CBF	-	Capacity Building Facility
CDCF	-	Community Development Carbon Fund
CDM	-	Clean Development Mechanism
CFC	-	Chlorofluorocarbon
CFL	-	Compact Fluorescent Lamps
CH+P	-	Combined Heat and Power
CMA	-	Capital Market Authority
CNG	-	Compressed Natural Gas
CO2	-	Carbon Dioxide
COMESA	-	Common Markets for Eastern and Southern Africa
COP	-	Conference of the Parties
CP	-	Cleaner Production
DEC	-	District Environment Committee
DMCN	-	Drought Monitoring Centre in Nairobi
EADB	-	East African Development bank
EIA	-	Environmental Impact Assessment
EIB	-	European Investment Bank
EMCA	-	Environmental Management & Coordination Act
EMS	-	Environment Management System
EPZ	-	Export Processing Zone
ERB	-	Electricity Regulatory Board
ESCOs	-	Energy Service Companies
ESDA	-	Energy Sustainable Development of Africa
FAO	-	Food and Agriculture Organisation
FD	-	Forest Department
FDI	-	Foreign Direct Investment
FFS	-	Farmer Field Schools
FPEL	-	Foreign Portfolio Equity Investment
GAW	-	Global Atmosphere Watch
GCOS	-	Global Climate Organisation System
GDP	-	Gross Development Product
GEF	-	Global Environment Facility
Gg	-	Gigagrammes
GHA	-	Greater Horn of Africa Region

GHG	-	Greenhouse gas
GOOS	-	Global Ocean Observing System
GTS	-	Global Telecommunication System
GUAN	-	Global Upper Air Network
HCFCs	-	Hydrochloroflourocarbons
HEPP	-	Hydro Electric Power Plants
HIE	-	High Income Economies
IBRD	-	International Bank for Reconstruction & Development
ICSID	-	International Centre for Settlement of Settlement of Investment Disputes
IDA	-	International Development Association
IDB	-	Islamic Development Bank
IEEN	-	Industrial Energy Efficiency Network
IFC	-	International Financial Corporation
IPCC	-	Intergovernmental Panel on Climate Change
IPPs	-	Independent Power Producers
IPRs	-	Intellectual Property Rights
ITCZ	-	Inter-Tropical Convergence Zone
JBIC	-	Japan Bank of Investment and Corporation
KAM	-	Kenya Association of Manufacturers
KARI	-	Kenya Agricultural Research Institute
KCB	-	Kenya Commercial Bank
KEFRI	-	Kenya Forestry Research Institute
KEMRI	-	Kenya Medical Research Institute
KENGEN	-	Kenya Electricity Generating Company
KIPI	-	Kenya Industrial Property Institute
KMD	-	Kenya Meteorological Department
KNCPC	-	Kenya National Cleaner Production Centre
KPC	-	Kenya Pipeline Company
KPRL	-	Kenya Petroleum Refineries Limited
KR	-	Kenya Railways
LCPDP	-	Least Cost Electric Power Development Plan
LPG	-	Liquefied Petroleum Gas
MDBs	-	Multilateral Development Banks
MIGA	-	Multilateral Investment Guarantee Agency
MOLG	-	Ministry of Local Government
MU	-	Moi University
NARC	-	National Rainbow Coalition
NBI	-	Nile Basin Initiative
NCCACC	-	National Climate Change Activities Coordinating Committee
NDF	-	Nordic Development Fund
NEAP	-	National Environment Action Plan
NEMA	-	National Environment Management Authority
NIB	-	Nordic Investment Bank
NMVOC	-	Non-Methane Volatile Organic Compounds
NOCK	-	National Oil Corporation of Kenya
NTF	-	Nigeria Trust Fund

OA	-	Official Aid
ODA	-	Official Development Assistance
OWS	-	Oil/Water Separators
PDF	-	Project Development Facility
PIEA	-	Petroleum Institution of East Africa
POPs	-	Persistent Organic Pollutants
PRGF	-	Poverty Reduction and Growth Facility
PV	-	Photovoltaic
PVMTI	-	Photovoltanic Market Transformation Initiative
R&D	-	Research and Development
RE	-	Renewable Energy
REP	-	Rural Electrification Programme
RETs	-	Renewable Energy Technologies
RTS	-	Regional Telecommunication System
SAPP	-	Southern African Power Pool
SCADA	-	Supervisory Control And Data Acquisition
SHS	-	Solar Homes Systems
SILs	-	Specific Investments Loans
SIMLs	-	Sector Investment Maintenance Loans
SMEs	-	Small and Medium Enterprises
STAP	-	Scientific and Technical Advisory Panel
TRIPs	-	Trade Related aspects of Intellectual Property Rights
UETCL	-	Uganda Electricity Transmission Company Ltd.
UN	-	United Nations
UNCED	-	United Nations Conference on Environment and Development
UNCTAD	-	United Nations Conference on Trade and Development
UNFCCC	-	United Nations Framework Convention on Climate Change
UNIDO	-	United Nations Industrial Development Organisation
UON	-	University of Nairobi
VOCs	-	Volatile Organic Compounds
WMO	-	World Meteorological Organisation
Wp	-	Watt Peak
WTO	-	World Trade Organisation

CHAPTER ONE

1. INTRODUCTION

The extent and scope of regional climate change impacts depend on the degree of mitigation. While the urgency and scale of adaptation efforts required will be lower if aggressive mitigation is undertaken early on, some degree of adaptation is inevitable. Even if greenhouse emissions were curbed immediately the global average temperature would still continue to rise due to the slow response of the earth's atmosphere to past emissions. This suggests that any future levels of greenhouse gas concentrations, once stabilized will be above current levels. Kenya intends to develop with international assistance a coherent response to adaptation, which will be integrated across key sectoral ministries.

Article 4.5 of the UNFCCC states that developed country Parties and other developed Parties included in Annex II "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 implement the provisions of the Convention."

The COP by its decision 13/CP.1 recalled the provisions of Chapter 34 of Agenda 21 on Transfer of Environmentally Sound Technologies (ESTs), cooperation and capacity building and requested the convention secretariat to prepare itemized progress report on concrete measures undertaken by parties listed in Annex II of the convention.

COP decision 4/CP.4 requested Subsidiary Body for Scientific and Technological Advice (SBSTA) to establish a consultative process aimed at achieving agreement on a framework for meaningful and effective actions to enhance implementation of Article 4.5.

Decision 4/CP.4 also urged non-Annex 1 Parties to submit their prioritized technology needs, especially those relating to key technologies to address climate change in particular sections of their national economies, taking into account state-of-the art environmentally sound technologies.

This report has been prepared in response to this decision and is intended to highlight the country's relevant technological requirements while showing the efforts the

country is making towards realization of her sustainable development goals. It also indicates the support needed so as to work with the global community in meeting the objectives of the Framework Convention on Climate Change.

Achieving the ultimate objective of the UNFCCC as formulated in Article 2, will require technological innovation and the widespread transfer and implementation of technologies and know-how for mitigation of greenhouse gas emissions. Transfer of technology for adaptation to climate change is an important element of reducing vulnerability to climate change. It has however not been considered in this study due to inadequate resources.

1.1 Method of Study

Method of Study included the preparation of a scoping document that gave a background to the UNFCCC and the Technology Needs Assessment process. This was discussed by a Technical Committee on Technology Needs Assessment composed of all relevant stakeholders. Terms of reference for work to be carried out under the various sectors identified under the Initial National Communication chapter on Mitigation Options were developed and experts from the relevant institutions identified. They carried out literature searches, reviewed national reports and documents to come up with reports on information on GHG emissions and technologies/practices in their areas of expertise.

These reports were reviewed and in-depth analysis carried out in workshops organized by the Technical Committee. After the finalization of the work, the compiled report was circulated to all stakeholders and a final workshop called to adopt the report.

1.2 Background on Technology Transfer Discussion under the UNFCCC

The ultimate objective of the UNFCCC aims at the stabilization of GHG emissions. It is stated in Article 2 that achieving this objective will require technological innovation and the widespread transfer of Mitigation technologies. Similar technological input will also be required to reduce vulnerability to climate change.

These technologies should be environmentally sound and address climate change and promote sustainable development.

The issue of technology is as old as the establishment of the United Nations. With the release of the Brundtland Report on Environment and Development in 1987, the subject of sustainable development took centre stage in all international environmental and development initiatives. The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 was the major outcome of the report. The Conference adopted the "Agenda 21" and 'Action Plan' for sustainable development.

Chapter 34 of Agenda 21 addresses the issue of technology transfer. The issues covered here include: -

1. Making available and promote in developing countries ESTs on concessional and preferential terms including expertise.
2. Relevant information on technological needs.
3. Capacity building to develop and manage ESTs, including human resource development and strengthen research and development capacities.
4. Development of indigenous technology and technology assessment.

Technology transfer has been seen as being achievable through long-term Technological partnerships between technology suppliers and recipients. Components of such a partnership could include: -

- Access to scientific and technical information.
- Promotion of technology transfer projects.
- Promotion of indigenous and public domain technologies.
- Capacity building
- Intellectual property rights.

The UNFCCC does have has strong provisions on technology transfer laying down the rules for both developed and developing countries. Developing countries accept to be involved in global efforts to address Climate Change and undertake the general provisions of Article 4.1 in return for assistance with finance and technology transfer that are set out in this Article.

Below are key provision relating to technology transfer under the UNFCCC.

Article 4.1.h: All Parties taking into account their common and differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances shall: - Promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change, and to the economic and social consequences of various response strategies.

Article 4.3: The developed country Parties and other developed Parties included in Annex II shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet their agreed full incremental costs of implementing measures that are covered by paragraphs I of this Article and that are agreed between a developing Country Party and international entity or entities referred to in Article 11 in accordance with that Article.

Article 4.4: Developed Country Parties and other developed Parties in Annex II shall also assist the developing countries that are particularly vulnerable to the adverse effects of climate change in meeting the cost of adaptation to those adverse effects.

Article 4.5: The developed country Parties and other developed Parties included in Annex II 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. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.

Article 4.7: The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing Country Parties.

The Kyoto Protocol in its Article 10 asks all Parties to cooperate in the promotion of effective modalities for the development, application and diffusion of ESTs. Furthermore, Parties are required to take all practical steps to promote, facilitate and finance as appropriate, the transfer of, or access to ESTs, practices and processes pertinent to climate change, in particular to developing countries.

1.3 Funding For Technology Transfer

The funding mechanism of the Convention is the Global Environment Facility. Until recently, the focus of the GEF was basically on mitigation to Climate Change, now adaptation has received some attention with the creation of a new GEF operational focal area on adaptation.

By decision 4/CP.4, the Conference of the Parties recommended a series of practical steps to promote, facilitate and finance the transfer of and access to ESTs and know how.

- It outlined the importance of supporting the development and enhancement of endogenous capacities and technologies of developing country Parties, and identified areas where assistance in facilitating the transfer of ESTs and know-how is required.
- It requested Annex II Parties to provide a list of ESTs and know-how related to adaptation to and mitigation of climate change that are publicly owned, and to report in their national communications steps taken to implement Article 4.5 of the Convention.
- It asked non-Annex I Parties to submit their prioritized technology needs and invited all Parties and interested actors to identify projects and programmes that can serve as models for improving the differences and implementation of clean technologies under the convention.

Following this decision, three regional workshops were held in Africa, Asia and the Pacific region, Latin America and the Caribbean. Through the consultative process, a framework for technology transfer was developed. This framework for meaningful and effective implementation Article 4.5 was formally adopted through decision 4/CP.7. This Technology Needs and Needs Assessment report is therefore carried out in fulfilling the above relevant articles and decision of the COP and go towards assisting Kenya meet her obligation under the UNFCCC.

1.4 Financial Resources Flows

If financial flows can be seen as a proxy for technology flows then it is evident that technology flows into the country have been small.

The country has pursued a variety of policies aimed at attracting foreign investors which have yet to bear fruit. More recently, the country has created an environment where it takes only 21 days to get the necessary approvals under the national laws to start project activities.

Technology flows are usually through Official Development Assistance (ODA), Foreign Direct Investment (FDI), technology sales and loans, and cooperation agreements such as those on Research and Development (R&D).

This includes grants and interest free or subsidized loans to developing countries and is primarily from OECD countries. It includes both bilateral aid and that provided by governments indirectly through multilateral organizations.

1.5 Loans at Market Rates

These include loans from the international institutions, including the Multilateral Development Banks (MDBs), and commercial banks. Some of the grant portions of ODA and Official Aid (OA) are also channeled through MDBs to subsidise their loan interest rates, blurring somewhat the lines between these categories.

Foreign Direct Investment (FDI) involves direct investment in physical plan and equipment in one country by business interests from a foreign country.

Commercial sales refer to the sale (and corresponding purchase), on commercial terms, of equipment and knowledge.

Foreign Portfolio Equity Investment (FPEI) and Venture Capital

These involve purchase of stock or shares of foreign companies through investment funds or directly. Venture capital is characterized of being longer term and higher risk, with a greater degree of management control exerted by the investor.

Other financial flows include Export Credit Agencies and activities supported by non-governmental organizations active in technology transfer efforts, educational training efforts not captured in the other indicators, and related transfers.

In the recent past, the country has actively put in place measures to attract foreign investors and indicators of investment flows do provide a measure of technology transfer. Of particular importance of financial resources flows is the resumption of Official Development Assistance (ODA) under the Poverty Reduction and Growth Facility (PRGF) and pledges made at the November 2003 Donor Consultative group meeting. Currently the country is experiencing an optimistic economic growth rate and massive investment resources are premised on Kenya securing more substantial external resources inflows in form of confessional financing and Foreign Direct Investment (FDI) as well as substantial increase in private investment.

It should be noted that FDI involves direct investment in physical plans and equipments in one-country business interests from a foreign country. In Kenya, legal framework for FDI is provided by the Companies Ordinance (Chapter 486), the Partnership Act (Chapters 20 and 30) and the Foreign Investment Protection Act. The government has carried out several economic reforms to attract more investment, which include: abolishing of export and import licensing except for items listed in the Imports, Exports and Essential Supplies act (Chapter 502), rationalizing and reducing import tariffs; revoking all export duties and current account restrictions; freeing of the shilling to be determined by the market; allowing residents and non-residents to open foreign currency accounts with domestic banks; and removing restrictions on borrowing by foreign companies and also allowing local residents to borrow form abroad. The table below shows the FDI flows to East Africa; 1986-2003

Table 1-1: FDI flows to Kenya and East Africa: 1986-2003 (Amounts in millions of US$).

	1986-1990	1991-1995	1996-2000	2001	2002	2003
Kenya	38.4	12.8	39.8	5.3	27.6	81.7
Tanzania	0.3	46.4	260.4	467.2	240.4	248.0
Uganda	0.6	46.4	200.9	228.6	249.3	283.3
East African Community (Kenya, Uganda and Tanzania)	39.3	105.6	500.3	701.1	517.3	613.0

Source: UNCTAD, FDI database

Foreign Portfolio Equity Investment/Venture capital

These involve purchase of stock or shares of foreign companies through investment funds or through direct purchase. Venture capital is characterized of being longer tem and higher risk, with a greater degree of management control exerted by the investor. However, the listing below outlines some selected indicators of Foreign Direct Investments (FDIs): -

- FDI inflows - Cross-border mergers and Acquisitions
- FDI outflows - Sales of foreign affiliates
- FDI inward - Gross product of freeing affiliates
- FDI outwards stock - Gross product of foreign affiliates
- Exports of foreign affiliates - Gross fixed capital formation
- GDP (in current prices - Royalties and licence fee receipts
- Exports of goods and Non Sector services

Table 1-2: Trend figures and statistics on the State of the Economy. Selected Key economic and social indicators, 1996-2000

Indicator	1996	1997	1998	1999	2000
Trend figures and statistics					
Growth of GDP at constant price (%)	4.6	2.4	1.8	1.4	-0.03
GDP at market prices (Ksh mn)	528,739.5	623,235.1	690,842.1	740,330.0	788,917.0
Inflation	9	11.2	6.6	3.5	6.2
GPP per capita (current) (Ksh)	17,095.9	19,988.4	21,267.1	22,207.7	22,942.9
GDP per capital (constant-1982)	3,722.0	3,707.5	3,665.0	3,613.3	3,527.7
Major Economic Activities					
Agriculture	135,572	151,614.2	163,086.4	155,574.2	140,189.4
Manufacturing output (Kshs mn)	16,001.0	18,703.6	21,008.6	29,954.8	53,667.0
Petroleum consumption in ('000 tonnes)	2,230.5	2,175.2	2,199.1	2,311.6	2,448.1
Electricity consumption (GWh)	3,487.9	3,671.7	3,601.8	3,685.2	3,320.7
Tourism earnings (Ksh mn)	25,600.0	22,640.0	17,509.0	21,367.0	19,593.0
Wage employment (000)	1,618.8	1,647.4	1,664.6	1,673.6	1,676.8

Source: Economic Survey, 2001

FDI incentive measures

The Government of Kenya has put in place several incentive measures so as to promote investments these include: An investment allowance of 60% countrywide in manufacturing and hotel sectors and at 100% for manufacturers under bond; liberal depreciation rates based on book value; offsetting of losses by future taxable profits; remissions from custom duties by lowering duties on capital goods; export promotion programs, which include the Export Processing Zone (EPZ) and manufacturing under bond; and market access which include regional markets such as the East African Community and common market for East and Southern Africa, African Caribbean and Pacific/Lome Convention.

Technical cooperation has been the main vehicle for technology flows into the country. There is still a great dependency in the country and this can be attributed to the

low amount of local Research and Development activities that are associated with the resource flows. Most of the Research and Development needed for product modifications and new products are still done at the parent company with minor product modifications occurring in the local subsidiaries.

1.6 The Financial Sector and Business Support Services

The Banking Sector

The banking sector in Kenya has been fairly stable with the number of commercial banks dropping while the number of non-bank financial institutions also experiencing a drop in terms of numbers. One characteristic of this sector is that the banks and other financial institutions offer very low deposit rates, which are not remunerative enough to encourage savings and hence investments and technology transfer.

The Capital Markets Authority

The Capital Markets Authority (CMA) has played a major role in spearheading reforms in capital markets, aimed at increasing investors' confidence. Kenya's stock market is organized into four independent segments: Alternative Investments Market Segment; Fixed Incomes Securities Market Segment; and Futures and Options Market Segments. The stimulation of new investments attracts new forms of technology transfer.

The Insurance Industry

The insurance industry is rather stable. In the recent past the industry has faced a number of challenges including reduced investment income, under-cutting of premium rates, fraudulent practices and narrow investment portfolios.

External Resources and ODA

- Resumption of ODA under the Poverty Reduction and Growth Facility (PRGF) and pledges made at the November 2003 Donor Consultative group meeting;
- Main challenges to fully utilize the new opportunities and the Government capacity to accelerate the implementation of requisite reforms (conditionality);
- Some key reform measures are not only expensive (such as retrenchment and parastatal restructuring) but also have important political dimension (cost sharing);

- Currently the country has an optimistic economic growth rate of 4.7%. Massive investment resources are premised on Kenya securing substantial external resources inflows in form of confessionals financing and FDI as well as substantial increase in private investment;
- Kenya is a signatory to a number of obligatory trade agreements (EAC, COMESA, ACP-EU, WTO etc), which require systematic alignment of its domestic trade and tariff policy regimes with commitments to the agreements.

Subsidies and Technology Transfer

Subsidies are favourable tax treatment, grants and soft loans, regulations that favour a particular technology and Research and Development funding.

- Reduction of costs for consumers and/or producers may be considered a subsidy. These might include grants, tax reductions and exemptions or price controls, regulations and standards that screw the market in favour of a particular fuel development.
- Country's fuel consumption path e.g. fossil fuels, unclear power, firewood, coal etc.
- Subsidies to renewable and energy-efficient end-use technologies are growing in response to environmental concerns, particularly climate change and local pollution.

  → Government could subsidise these technologies to enhance access to electricity in remote areas

  → Diversify fuel mix and promote decentralised generation

Table 1-3: Subsidies and Technological Needs Assessments

	Environmental effects	**Social effects**
1.	If subsidies are to go to fossil fuels, removing them would reduce noxious and CO_2 emissions	Significant short-term distributional effects, mainly due to impact on employment and household spending on energy
2.	By encouraging over-consumption, under-pricing contributes to pollution and green house gas emissions	Savings form subsidy removal can finance welfare payments to the poor
3.	Subsidies exacerbate pollution, and especially particulates and lead	Reducing subsidies would free up resources to support the poor in more effective ways

Table 1-4: The International Financing of Technology Transfer

Technology Transfer Pathway	**Relative Importance of Type of Financial Flow of Technology Transfer Pathway**					
	Official Development Assistance	**Loans**	**Commercial Sales**	**Foreign Direct Investment**	**Foreign Portfolio Equity Investment**	**NGO and other flows**
Government	+++	++	+	+	+	+
Private Sector	-	+++	+++	+++	++	-
Community	++	-	-	-	+	+++

KEY: *+++ Primary Component of pathway, ++ Secondary Component of pathway, + Minor component of pathway.*
Source: *Methodological and Technological issues in Technology Transfer, IPCC. 200*

Funding Sources

The section below provides valuable information about funding sources for environmental projects in developing countries from which Kenya has been a beneficiary and about models that can be used to assist in finance and investment decisions. The information contained in this section is not intended to be exhaustive and does not imply endorsement of any institution, organisation or source of funding.

1.7 Financing by Multilateral Development Banks

The Multilateral Development Banks (MDBs) have seen technology transfer as part of their mission to encourage development. More recently they started to focus on the challenges of the environment and the specific problems involved in transferring environmental technology. In response many have started to develop a range of initiatives activities.

A number of Multilateral Development Banks (MDBs) provide financing through long term loans based on market rates, very long term loans with interest well below market rates (often termed 'credits') and grants (mostly for technical assistance, advisory services or project preparation).

Other institutions and funds with more narrow memberships and areas of interest also have been established for development purposes or have a development mandate. Additional entities of interest include the European Investment Bank (EIB), International Fund for Agricultural Development (IFAD), Islamic Development Bank (IDB), Nordic Investment Bank (NIB) and East African Development Bank (EADB).

1.7.1 World Bank Group

The World Bank Group consists of five closely associate institutions: -

1. The International Bank for Reconstruction and Development (IBRD) focuses on reducing poverty in middle income and credit-worthy poorer countries by providing loans linked to market rates, guarantees and non-lending services.

2. The International Development Association (IDA) provides zero interest loans (credits) to the world's poorest countries, especially in the areas of primary education, basic health, and water supply and sanitation.

3. The International Finance Corporation (IFC) furthers economic development through the private sectors.

4. The Multilateral Investment Guarantee Agency (MIGA) provides international facilities for conciliation and arbitration of investment disputes.

5. The International Centre for Settlement of Investment Disputes (ICSID) provides international facilities for conciliation and arbitration of investment disputes.

The term 'World Bank' refers specifically to the first two institutions listed – the IBRD and the IDA. The following sections provide additional information on the World Bank and IFC only.

1.7.2 World Bank

While the IBRD focuses on middle-income countries, and the IDA focuses on the poorest developing countries, some countries are eligible for a blend of IBRD and IDA funds.

The financial services provided by the World Bank include lending instruments; co-financing, trust fund and grantees; and grants. Most Investment projects use Specific Investments Loans (SILs) or Sector Investment and Maintenance Loans (SIMLs). Co-financing refers to funding committed by an external official bilateral or multilateral partner, an export credit agency, or a private source in the context by a specific Bank-funded project. Trust funds enable the Bank, along with bilateral and multilateral donors, to mobilize funds for investment operations, as well as debt relief, emergency reconstruction, and technical assistance. Guarantees promote private financing in borrowing member countries by covering risks the private sector is not normally ready to absorb or manage. Grants provide seed money for pilot projects with the innovative approaches and technologies.

The World Bank itself is limited by its charter to only working with governments and quasi governments organisations, although it is increasingly developing mechanisms to deal with private and quasi-private sector entities. Its affiliate, the International Finance Corporation (IFC) is most directly involved in private sector investment. However, the World Bank has developed a number of initiatives with the potential to support environmental technology transfer. These include financing a number of environmental lending programmes at domestic financial institutions, which will then lend to industry. The World Bank's Carbon finance initiatives are part of the larger global effort to combat climate change, and go hand in hand with the Bank's mission to reduce poverty. Through its Carbon Finance Business, the Bank is trying to ensure that the poorer countries can benefit from international efforts to address climate change including taking

advantage of the emerging carbon market for greenhouse gas emission reduction. An important new World Bank initiative is the Prototype Carbon Fund. This vehicle provides additional finance for CO_2 mitigating projects in return for the offsets, i.e., the right to transfer the credit for the Co_2 saved to the investor. It has a substantial private sector financing and project execution. PCF's primary focus is on renewable and alternative energy technologies. As of September 2002, the World Bank created the Community Development Carbon Fund to provide Carbon Finance to small-scale projects in small countries and poorer rural areas of the developing world. The Fund is a private-public initiative established as a Trust Fund, similar to the Prototype Carbon Fund and is administered by the Bank. Poorer rural communities, especially in small and less developed countries were recognized as being likely to be by-passed by Carbon Investors. Concern over this market bias led Parties to the UNFCCC to find ways to reduce the transaction costs of small-scale projects. The fund will work with local intermediaries to lower the transaction costs and risks of developing small-scale projects.

1.7.3 International Finance Corporation (IFC)

The IFC is the largest multilateral source of debt and equity financing for private sector projects in the developing world. It has helped develop, structure and implement a number of private equity funds designed to target the environmental sector.

Described in the following sections are two IFC units of particular in the field of Environmental Protection and Conservation. The Environmental Division of the Technical and Environment Department and the Small and Medium Enterprise Department.

1.7.4 Environmental Division

The Environmental Division consists of three units: -

1. The Environmental Division consists of three units, which reviews and monitors the impact of IFC investments.
2. The Environmental Project unit, which develops innovative projects to address environmental concerns and serves as IFC's implementing agency for the GEF.
3. The Financial Markets Unit, which reviews, monitors, and provides technical assistance to financial intermediaries and conducts internal and external environmental training programs.

Small and Medium Enterprises Department

The Small and Medium Enterprise Department seeks to promote local small business growth in developing nations. This work is carried out by Project Development Facilities (PDFs) around the world and by the Department's Capacity Building Facility (CBF), in partnership with experienced external organisations and other World Bank Group partners.

Through the PDFs, the IFC and its partnership provide local entrepreneurs with technical assistance needed to build commercially viable businesses and to take other broader initiative to develop sustainable and dynamic Small and Medium Enterprises (SMEs). The facilities help SMEs attract necessary financing for their ventures, giving priority to projects with the potential to develop self-sustaining enterprises, generate employment, increase skills, and stimulate export earnings. Nine PDFs are now in operation 3 of direct relevance to Africa Project Development Facility and North Africa Enterprises Development.

1.7.5 African Development Bank Group

The African Development Bank Group is a Multinational Development Bank supported by 77 nations. It contains three institutions: -

1. The African Development Bank (ADB), whose principal functions are to: -

    - Make loans and equity investments for the economic and social advancement of the member countries in Africa.

- Provide technical assistance for the preparation and execution of development projects and programs.
- Promote investment of public and private capital for development purposes.
- Respond to requests for assistance in coordinating development policies and plans of the member countries in Africa.

The ADB also gives special attention to national and multinational projects and programs that promote regional integration. The ADB's operations emphasize agriculture, public utilities, transport, industry, health and education. Its concerns cut across sectors, such as poverty reduction, environmental management, gender mainstreaming and population activities. Most ADB financing is designed to support specific projects. The ADB also provides program, sector ad policy-based loans, however, to enhance national economic management.

2. The African Development Fund (ADF) provides development financing on concessional terms to low-income member countries that are unable to borrow on the non-concessional terms of the ADB. Reducing poverty is the main aim of ADF development activities in borrowing countries. ADF finances projects, technical assistance, and studies.

3. The Nigeria Trust Fund (NTF) provides below-market financing for projects of national or regional importance.

1.7.6 European Bank for Reconstruction and Development

The European Bank for Reconstruction and Development (EBRD) was established in 1991 to support the development of a private sector in the countries of Central and Eastern Europe and the Former Soviet Union. It is the largest single investor in the region and invests primarily in private enterprises, usually with commercial partners.

Investments in large projects, generally not smaller than ∈5 to 15 millions, can include various types of loans, equity and guarantees. Among other criteria, the project must have good prospects for being profitable and include significant equity contributions, in cash or in kind, from

the project sponsor. The EBRD does not subsidize projects, and its loans are based on current market rates.

Many projects are too small to be funded directly by the EBRD. To give entrepreneurs and small firms greater access to finance, the EBRD supports financial intermediaries, such as local commercial banks, micro-business banks, equity funds and leasing facilities. Investment criteria are consistent with EBRD policy, but financial intermediaries make independent decisions about which SMEs they fund.

1.8 Global Environment Facility

The Global Environment Facility (GEF) helps developing countries fund projects and programs that protect the global environment. GEF is the official financing mechanism for the United Nations Framework Convention on Climate Change, the United Nations Framework on Biological Diversity, the United Nations Framework Convention on Combating Desertification, the Stockholm Convention on Persistent Organic Pollutants (POPs) and the Montreal Protocol. It is a unique international collaborative effort that provides grant and concessional funding to address six global concern:- 1) biodiversity loss; 2) Climate Change; 3) degradation of international water; 4) Ozone depletion; 5) Land degradation; and 6) persistent organic Pollutants. GEF funds the incremental costs associated with transforming a project with national benefits into one with global benefits.

Established in 1991, the GEF has allocated $4 billion in grants and leveraged an additional $12 billion in co-financing to support more than 1,000 projects in more than 140 developing countries and those with economies in transition. In August 2002, 32 donor countries pledged nearly $3 billion to fund the GEF for the next four years.

The GEF organisation structure includes the Assembly, the Council, a Secretariat, three Implementing Agencies, and the Scientific and Technical Advisory Panel (STAP). The work program is implemented through three Implementing Agencies – the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank – in a manner reflective of their different areas of expertise and missions. UNDP plays the primary role in ensuring the development and management of capacity-building programs and technical assistance projects. UNEP plays the primary role in catalyzing the

development of scientific and technical analysis and in advancing environmental management in GEF financed activities. The World Bank plays the primary role in ensuring the development and management of investment projects.

GEF operations are organized into the following three broad categories: -

1. **Enabling Activities:** Projects that fulfill essential communications requirements of a treaty or convention provide a basic and essential level of information to enable policy and strategic decisions to be made, or assist planning that identifies priority activities within a country.

2. **Operational Program:** Conceptually integrated sets of projects that achieve a global environmental objective in one of the six areas of concern previously identified. As of May 2000, there were 12 operational programs: four in biodiversity, four in Climate Change (specifically, Removal of Barriers to Energy Efficiency and Energy Conservation, Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs, Reducing the Long-Term Costs of Low Greenhouse Gas Emitting Energy Technologies, and Promoting Environmentally Sustainable Transport), three in international waters, and one in Integrated Ecosystem Management.

3. Short-term response measures: Projects that yield short-term benefits at low cost but are not expected to yield significant strategic or programmatic benefits.

Funding options are organized into six categories: 1) full size projects, 2) medium sized projects, 3) enabling activities, 4) project preparation and development facility, 5) small grants program, and 6) the SME program. The SME is a partnership with the IFC, an affiliate of the World Bank, and is addressed in more detail in this appendix.

Although most GEF funding is directed to government agencies, any individual or group may propose a project idea if: -

- The country in which the activities are to occur is eligible for funding.

- The project reflects national or regional priorities and has the support of the country or countries involved.
- The project improves the global environment or advances the prospect of reducing risks to it.

Country eligibility to receive funding is determined to two ways: 1) Developing countries that have ratified the relevant treaty are eligible to propose biodiversity and Climate Change projects; 2) Other countries, primarily those with economies in transition, are eligible if the country is a party to the appropriate treaty and is eligible to borrow from the World Bank or receive technical assistance grants from United Nations Development Programme (UNDP).

Project ideas from proponents should be addressed to the government concerned, through the GEF Focal Point within the government, and to one of the Implementing Agencies. The choice of agency is up to the government and/or the project proponent, and proponents might wish to consult the GEF Focal Point first. A list of country Focal Points and their contact information is available on the GEF website. GEF projects are developed and implemented by one of the Implementing Agencies, in consultation with country governments.

Several existing projects engage private firm, private industries, and associations in one or more components of the project. More than 12 Climate Change Projects funded by the GEF involve participation of Energy Service Companies (ESCOs) for the delivery and maintenance of electricity in both grid and non-grid types of systems. Seven rural energy projects make use of local electricity cooperatives, many of which are owned and managed by small-scale entrepreneurs.

Table 1-5: Climate Projects Implemented including those already forwarded to the GEF (in Kenya)

Project Name	I_Agency	Focal area	Status	Executing Agency	Scope	Total cost
GEF-KAM Industrial Energy Efficiency Project	UNDP	Climate Change	Ongoing	Kenya Association of Manufacturers	National	
African Rift Geothermal Development Facility (ARGeo)	UNEP	Climate Change	Ongoing	Kreditanstalt fur Wiiederaufbau (kfw) and UNEP in collaboration with a network of national agencies	Regional	237.700 US$m
Monitoring of Greenhouse Gases including Ozone	UNDP	Climate Change	Complete	World Meteorlogical Organization	Global	6.000 US$m
Solar and Wind Energy Resource Assessment	UNEP	Climate Change	Complete	UNEP/DITE	Global	9.320 us$m
Photovoltaic Market Transformation Initiative (IFC)	IBRD	Climate Change	Ongoing	IFC	Global	120.375 US$M
Expedited Financing of Climate Change Enabling Activities Part II: Expedited Financing for (interim) Measures for Capacity Building in Priority Areas	UNEP	Climate Change	Ongoing	Ministry of environment and Natural Resources	National	0.248
Ormat Olkaria III Geothermal Power Development	IBRD	Climate Change	Ongoing	IFC	National	185.025 us$m
Removal of Barriers to Energy Conservation and Energy Efficiency in Small and Medium Scale Enterprises	UNDP	Climate Change	Ongoing	KAM	National	120.375 us$m
Joint Geophysical Imaging (JGI) Methodology for Geothermal Reservoir Assessment	UNEP	Climate Change	Ongoing	Kenya Electricity Generating Company (KenGen) as Executing Agent for Geothermal Exploration and Development for the Ministry of Energy	Regional	2.733 US$m
Enabling Activities for the Preparation of Initial National Communications Related to the UNFCCC	UNEP	Climate Change	Complete	National Environment Management Authority	Regional	0.248 US$m
Capacity Building on Policies and Regulatory Mechanisms Promoting Renewable Energy in Electricity Market Reforms in Kenya	UNEP	Climate Change	NFP Endorsed	Ministry of Energy	National	GEF: US$387000
Building Sustainable Commercial Dissemination Networks for Household PV Systems in Eastern Africa	UNEP	Climate Change	NFP Endorsed	Kenya, Tanzania, Uganda, Ethiopia, Eritrea	Regional	1,257,630
Building capacity in sub-Saharan Africa to respond to the UN Framework Convention on Climate Change	UNDP	Climate Change	Complete	National Environment Management Authority	Regional	
Alternative to Slash and Burn Agriculture Climate Change	UNDP	Climate Change	Complete		Regional	
Integrated Strategy for Promoting Sustainable Response to Climate Change	UNDP	Climate Change	NFP Endorsed		National	
Mitigation of Climate Change	IBRD	Climate Change	NFP Endorsed	Total Kenya	National	
Anaerobic Biodigester for Nairobi City Council	UNDP	Climate Change	NFP Endorsed	Timmark Ltd	National	
Strengthening the Ministry of Energy's Capacity in Renewable Energy Activities	UNDP	Climate Change	NFP Endorsed	Ministry of Energy	National	

Project Name	I_Agency	Focal area	Status	Executing Agency	Scope	Total cost
Climate Change Capacity Building	UNDP	Climate Change	Complete	Ministry of Environment and Natural Resources	National	
Energy Conservation	UNDP	Climate Change	NFP Endorsed		National	
Centre for Promotion and Education of Solar Energy Utilisation	IBRD	Climate Change	NFP Endorsed		National	
Small Scale Wind Power Pilot Project for Rural Areas	IBRD	Climate Change	NFP Endorsed	Environmentalists Sans Frontieres (ESF)	National	
Energy Production Through Solid Waste Management In Kenya-Taka Nguvu (TN)	UNDP	Climate Change	NFP Endorsed	Taka Nguva Ltd.	National	Total USD 106'300
Climate Awareness Programme	UNEP	Climate Change	NFP Endorsed	Ministry of Environment and Natural Resources	National	
Soil-Carbon Stock and Change at National Level	UNEP	Climate Change	NFP Endorsed	Kenya Soil Survey	National	
Climate, Water and Agriculture: Impacts on and Adaptation of Agro-Ecological Systems in Africa	IBRD	Multi-Focal	Ongoing	Government	Regional	1.240 US$m
Coping with Drought and Climate Change: Best use of climate Information for Reducing Land Degradation and conserving Biodiversity.	UNDP	Multi-Focal	Pipeline	UNOPS/Government	Regional	14.426 US$m
Assessment of Soil Organic carbon stocks and change at National scales	UNEP	Multi-Focal	Ongoing	International Development Centre of the University of Reading, UK,	Global	2.002 US$m
Mount Kenya Pilot Project for Land and water Management	UNDP	Multi-Focal	Ongoing	IFAD	Regional	25.046 US$M
National Capacity Needs self-Assessment for Global Environmental Management (NCSA)	UNEP	Multi-Focal	Ongoing	National environmental secretariat Ministry of Environment and Natural Resources	National	0.161 us$m
Western Kenya Integrated Ecosystem Management Project	IBRD	Multi-Focal	Ongoing	Kenya Agricultural Research Institute (KARI/KEFRI)	National	Project Cost 9.550 US$m
Capacity Building for Watershed Management	UNDP	Multi-Focal	NFP Endorsed	Organization for Development Management	National	
Finalization of the Action Plan on the Environment Component of the New Partnership for Africa's Development	UNEP	Multi-Focal	NFP Endorsed	Govts	Regional	

The above table shows that the climate change projects implemented in Kenya are small technical assistance projects. The reasons for this could be attributed to lack of skills in developing climate projects. It is difficult for national experts to understand the criteria and requirements for climate change projects, how to differentiate the local interest and global benefit. The capacity need is in having a well-trained group of experts across relevant sectors.

1.9 Private Sector Sources

The Global Environment Facility is a financial mechanism that was established prior to the 1992 Earth Summit to provide grant and concession finance to recipient countries for projects and activities that aim to protect the global environment. There are three official implementing agents, UNDP, UNEP and the World Bank. The World Bank also acts as trustee of the GEF Trust Fund. The focus of the GEF is on providing incremental funding for projects that would not be viable on the basis of domestic considerations alone. The GEF has supported a growing but proportionately small number of private sector investment operations. As part of its private sector portfolio, the GEF put aside some funds in commitments to the IFC for climate change mitigation initiatives. A requirement for funding by the GEF is the demonstration of incremental global environmental benefits. This can be a time consuming and expensive process that increases transaction costs, although these problems are more marked with the Biodiversity Convention than support provided under the UNFCCC. The Buenos Aires Conference (COP 4) also officially expanded the scope of the GEF, for example, to include adaptation.

A number of private sector sources also invest in environmentally beneficial projects. Many of these sources receive significant support from Public institutions, such as MDBs. Most of these sources operate outside Africa. However, the few listed below have supported enterprises in Africa too.

1.10 E&CO

E&Co is a US-based group that provides business development services and seed capital to economically, socially and environmentally sustainable energy enterprises in developing countries. Its mission is to create viable local enterprises that deliver affordable and clean energy to those in need. To date, the group has supported more than 60 enterprises in Africa, Asia and Latin America.

E&Co provides early stage investment ($25,000 to 250,000)in either loans or equity to enable entrepreneurs to further develop their approach or begin implementation or construction of projects. Investments typically reflect near market terms and conditions, but E&Co will tolerate a

higher level of risk without seeking classic venture capital returns. Projects must have the potential to be self-sufficient and to attract private investment in the next stages of the development cycle. Where appropriate, assistance is provided in identifying co-financiers and/or later stage funders and works with the sponsor in preparing and presenting submissions to these organisations.

1.11 Solar Development Group

http://ifcln.ifc.org/enviro.nsf/Content/SolarDevelopment

Solar Development Group (SDG) is a source of capital and strategic business development support for developing country enterprises in the off grid solar energy service sector with potential for profitable growth. Eligible companies include: -

- Retailers or distributors of solar home systems or other related products.
- Renewable energy service companies, providing equipment on a fee-for-service basis.
- Banks and leasing companies with consumer credit programs for photovoltaic solar systems.
- System integrators.
- Importers of solar products.
- Local equipment assemblers and manufacturers of solar modules and system components.

The group consists of two entities: -

1. **Solar Development Capital** is a commercial private equity fund that seeks commercial rates of return. It makes debt and equity investments structured according to the financial need and cash flow capabilities of the company. Solar Development Capital encourages joint co-investment with other parties and typically exists from its investments after a five-to seven-year period. The size of the investments generally range from 100,000 to 2 million.

2. **Solar Development Foundation** is a non-profit organisation that provides support, ranging from $5,000 to $100,000, to help companies prepare for substantial growth and attract future capital. These business development services can be financed through low-interest loans and/or small grants.

Various international agencies also harness considerable expenditure. Most notable, the UN Development Programme makes substantial grants in the area of institutional capacity building. It has also directly supported the development of various financial mechanisms to encourage environmental technology transfer, such as supporting the feasibility work for an environmental venture capital fund.

CHAPTER TWO

2. ENVIRONMENTAL CONTEXT

2.1 Introduction

Achieving the ultimate objective of the UNFCCC will require technological innovation and the rapid and widespread transfer and implementation of technologies and know-how for mitigation of GHG emissions as well as technologies for adaptation to climate change. In this chapter is a summarized version of Kenya's national circumstances, GHG emissions inventory clearly showing areas that can benefit from technology transfer, and therefore contribute to the ultimate objective of the Convention, general description of steps to implement the convention and the vulnerable sectors of the economy.

2.2 National Circumstances

2.3 History and Geography

Kenya became independent on 12th December 1963. There are 42 ethnic groups each with its own cultures and traditions, some of which are influenced by climate conditions. For example, some communities are predominantly farmers, while other are pastoralists, fishermen, traders, etc. These ethnic groups have, over many years, developed coping mechanisms for climatic variations.

Kenya covers an area of about 592000 Km^2. It lies approximately between latitudes 5^o north and 5^o south and between longitudes 34^o and 42^o east on the east coast of Africa. The equator bisects the country in almost two equal parts. The altitude varies widely from sea level to about 5000 meters above sea level on the central highlands. Lakes occupy about 2% of total area, 16% is occupied by agriculturally highly potential areas, while arid and semi-arid lands occupies the reminder.

2.4 Climate

The country's climate is influenced by nearness to the equator, topography, the Indian Ocean, and the Inter-Tropical Convergence Zone (ITCZ). The influence of the ITCZ is modified by the altitudinal differences, giving rise to varied climatic regimes. Annual rainfall in Kenya follows a strong bimodal seasonal pattern. Generally, the

long rains occur in March – May, while the short rains occur in October – December, but with variations.

2.5 Ecosystem

Kenya is endowed with a variety of habitats and ecological systems, including wildlife, forests, lakes and rivers, wetlands, farmlands, vegetation, marine life forms and micro-organisms. Tourism mainly depends on wildlife, the beach and scenic features. The tourism sector is second to tea in foreign exchange earnings and a major employer in Kenya. Biological diversity is crucial for ecological stability including regulation of climate, economic development, creation, recreation, medicinal use, socio-cultural use and scientific advancement. Protection of ecosystems and plant diversity has the potential of enhancing climate change mitigation capacity.

2.6 Population

Kenya has a population of 28.7 million people in 1999, of which about 80% live in rural areas. The population distribution is uneven from an average of 230 persons per km^2 in high potential areas to an average of 3 persons per km^2 in arid areas. Over 50% of the population is below 15 years. However, intercensal population growth rate has declined significantly from 3.9% per annum for 1969 – 1979 to 2.9% for 1989 – 1998.

2.7 Land-use

About 16% of total land area is of high to medium agricultural potential and supports about 80% of the country's population. The remaining 20% of the population live in the remaining 84% of the total land area which is arid and semi-arid (ASAL). If climate change results in reduced precipitation in Kenya, then area of ASAL will increase, while the high potential ones would diminish in size.

2.8 Economic Factors

Real growth of GDP has been fluctuating over the years showing a downward trend since early 1990s reaching a negative – 0.3% in the year 2002. Consequently, poverty has been increasing. The underlying causes for poverty are many, the main ones being poor state of infrastructure, depressed investments, declining tourism activities, slump

in industrial production, deteriorating terms of trade and increasing climatic variations.

Poverty contributes to unsustainable use of resources and environmental degradation, such as poor farming practices, overgrazing and reliance on wood as the main source of energy. This is because the immediate survival needs of people often take precedence over the long-term needs public debt which has been increasing is an enormous economic burden.

2.9 Services

The service sector which include public transport, informal sector, building and construction, banking and finance, storage, trade, communications, tourism, distribution and other services contributes over half of Kenya's GDP and provides over two-thirds of total employment. The potential contribution of the service sector to GHG emissions is through transportation, dumping of waste and deforestation.

2.10 Informal Sector

The informal sector, also referred to as the Jua Kali includes all semi-organized and unregulated small-scale activities largely undertaken by self-employed or those employing only a few workers, but excluding all farming and pastoralist activities. It has grown considerably over the last 20 years, employed about 2,987,000 people in 1997 and 3,353,000 in 1998. It represents about 8% of GDP. It is the second largest source of employment after small-scale agriculture.

2.11 Climate Indicators

Indicators of climate change include weather variability, floods, droughts, increased greenhouse gas emissions, temperature changes, etc. Potential use of indicators include alerting decision-makers in government, business, industry, research and civil society organisation and global community to prioritize issues, guide policy formulation, and foster common understanding with a view to initiating action. Indicators will also be useful in determining mitigation options and capacity required. Extreme climate events are associated with disasters and increase in incidences of diseases. Incidences of vector and waterborne diseases increase during periods of heavy rains and flooding, while droughts and high temperatures

cause famine and malnutrition thereby weakening resistance to diseases.

2.12 Financial Resources

About 91% of total expenditure for research and development funding in 1998/99 was from the public sector, which was equivalent to 0.6% of GDP. The funds were given to various research institutions. Public research expenditure is heavily biased against industrial research, although the industrial sector is a major source of carbon dioxide. Mobilization of financial resources is critical and in this light, Kenya welcomes projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol (Article 12) and the Global Environment Facility.

2.13 Policy and Institutional Agreements

Policies for sound environmental management and sustainable use of resources and appropriate responses to climate change are articulated in a number of official documents. The sector specific policies relevant to adaptation and mitigation of climate change include those for agriculture, forestry, population, energy, water and industrialization. The Environmental Management and Coordination Act (EMCA) of 1999 is a framework legislation with provisions for economic incentives, enforcement mechanisms, protection and conservation of the environment, environmental quality standards including issues relating to emissions, impact assessment and modalities for implementing international treaties, conventions and agreements.

EMCA has created an appropriate institutional framework for the effective management of the environment, which supercedes the existing structures.

2.14 Greenhouse Gas Emissions by sector

The results produced here are as were reported in Kenya's Initial National Communication which was based on the findings of studies conducted by the Greenhouse Inventory Technical Working Group using the IPCC reference methodology to estimate GHG emissions. The studies developed the inventory of GHG from five sectors namely, energy, land use change and forestry, agriculture, industrial processes and waste management (table 1.1) using the revised IPCC guidelines (1996) for national gases inventories.

The gases emitted were methane (750 Gg), whose highest emissions are from the agricultural sector (576 Gg) followed by energy sector (148 Gg). Other GHGs emitted were N_2O (1.4 Gg) mainly from the energy sector (1.3 Gg), Gases emitted with indirect GHG effect includes; Oxides of Nitrogen, NOx (50.9), CO (1645.3 Gg), and NMVOC (6.) Gg).

Table 2-1: Summary of GHG emissions from anthropogenic activities in Kenya in 1994 (in Gigagrammes) (Gg)

Sector	Gas Type					
	CO_2 units	**CH_4**	**N_20**	**NOx**	**CO**	**NMVOC**
Energy	4522	148	1.3	46.7	1645.3	-
Industry	990.1	-	-	1.5	5.6	6.0
Agriculture	-	576	-	-	-	-
Land use /Forestry	**-28261**	11	0.1	2.7	9.4	-
Wastes	-	15	-	-	-	-
Total	**-22751**	**750**	**1.4**	**50.9**	**1660.3**	**6.0**

Kenya is a net carbon dioxide sink, absorbing about 22,751 Gg CO_2 per annum. This is due to regeneration of forest and non-forest trees. Methane emissions were largely from the agriculture sector, followed by the energy sector. The contribution of the waste sector was highly reduced due to the open nature of the waste disposal methods.

Carbon dioxide is the major greenhouse gas emitted. More than 65% of CO_2 emitted is from the transport sector, which is the largest consumer of petroleum products in Kenya. The second largest source of carbon dioxide (CO_2) emission is the industrial sector, mainly cement production. Other important gases emitted include carbon monoxide (CO), methane, oxides of nitrogen (NOx) and nitrous oxide (N_2O). The agricultural sector (including livestock production) is the major emitter of methane (over 70%) followed by the energy sector. The largest source of methane in the agricultural sector is enteric fermentation. Although, synthetic fertilizers are a source of nitrous oxide, their total emission is low due to limited use of fertilizers in the country.

2.15 Greenhouse Gas Mitigation Options

Attaining the ultimate objective of the convention requires the participation of all Parties in reducing GHG emissions enhancing sinks. While Kenya is currently a net sink, with increase in socio-economic development and more

specifically as the country works to attain its goal of industrialization by the year 2020, GHG emissions will increase. On the global scale, Kenya's contribution is negligible but the country is concerned about the protection of local and global environment more especially as the country is extremely vulnerable to the impacts of climate change.

Kenya is committed to work with the international community to combat climate change and has identified mitigation options, which if assisted to implement would achieve the twin objectives of sustainable economic development and GHG mitigation. The areas studied included: energy, transport, industry, agriculture, forestry and waste management sectors.

Energy: The main sources of energy used are, namely: biomass, petroleum, and the electricity. In terms of quantity, wood fuel accounts for over 70% of the total national consumption. Petroleum is the most important conventional energy source accounting for over 23% of the total national energy consumption. The government and relevant stakeholders in the sector are actively involved in developing and implementing measures for abatement of adverse climate change effects and supporting the use of fuel-efficient equipment.

Transport: The transport sector comprises five major types: road, rail air, sea/lake and pipeline with the road transport dominating. Transport plays a crucial role in the country's development and integration. Motorized transport is by far the most dominant and is a major source of pollution and emitter of GHGs, especially in the urban areas. Rail transport too is significant contributor of Greenhouse gases (GHG). The sector accounts for 56% of the fossil fuels consumed nationally. This is likely to rise in future due to the rapidly rising demand for motorized transport. The main GHG from the sector are carbon dioxide (CO_2), Non-Methane Volatile Organic Compounds (NMVOC's), NOx and Nitrous Oxide (NO_2). CO_2 is the major GHG. Road and rail transport are principal sources of GHG. Efforts will therefore be expended to identify measures that will lead to the control of CO_2 emission from these modes of transport.

The port of Mombasa serves an extensive hinterland in Kenya and surrounding countries namely; Uganda, Rwanda, Sudan, Ethiopia, Burundi and the Democratic Republic of Congo. The heavy commercial vehicles (predominantly diesel users),

which pass through the country, are responsible for heavy emissions of GHG and the destruction of roads.

The following measures have been identified as relevant in mitigating climate change impacts in the transport sector:-

- Encouragement of mass transport;
- Tuning of vehicles, improvement of telecommunications of reduce commuting by vehicles;
- Improved traffic management;
- Promotion of non-motorized transport;
- Inclusion of fuel efficiency in driving schools curricula;
- Improved parking arrangements in major towns;
- Environmental standard for transit vehicles; and
- Compulsory inspection of all vehicles.

A number of measures are already being implemented. These measures include:-

- Promotion of rail transport,
- Extension of oil pipeline, taxation, and
- Pollution control. There remains still a lot of work to be done, especially studies on: demand forecasting, vehicle stock analysis, transport planning and managements, development of databanks and models, and improvements in technology.

Agriculture: Kenya relies heavily on agriculture for food security, economic growth, employment creation, stimulation of growth in off-farm employment, and foreign exchange earnings. About 80% of Kenya's population live in rural areas and depend directly or indirectly on agriculture for their livelihoods.

There have been many cases of land degradation and pollution from the sector. For example, improper use of agro-chemicals has polluted water sources, poisoned and compacted soils. Agricultural intensification is likely to accelerate land degradation and put additional pressure on water, soil, forestry and wildlife resources and has potential to increase emissions of anthropogenic greenhouse gases (GHG) into the atmosphere.

A wide range of measures and policy instruments have been adopted aiming at sustainable development but have also met the objective of addressing GHG emissions in the agriculture sector. These include economic instruments

such as subsidies/taxes, regulatory measures, and information sharing and research and development projects.

The major constraints to the implementation of mitigation options in the agriculture sector include high financial costs, lack of quality data and information, inadequate extension services, inappropriate technologies, inadequate policies and lack of economic incentives. Approaches to overcome these constraints include provision of financial resources, timely dissemination of quality data and information and formulation of appropriate policies. The enforcement of the Environmental Management and Coordination Act will go along way in ensuring harmonization of environmental policies. The ensuring harmonization of environmental policies in Kenya including facilitating implementation of the mitigation options.

Industry*:* Industrial activities, which emit GHGs, include manufacture of goods, mining and quarrying; building and construction, electricity generation, food processing and hospitality services. Emission measures have been implemented by some industries in Kenya for considerations other than climate change. Minimizing consumption of fossil fuel and promoting afforestation and reforestation programmes will significantly mitigate emission of GHG into the atmosphere.

Environmental concerns are considered in Sessional Paper No.2 of 1997 on the Industrial Transformation to the Year 2020. Some of the legislation which contribute to mitigation measures are: Environment Management and Coordination Act, the Factories and Other Places of Work Act (Cap. 514), the Local Government Act (Cap. 265) Public Health Act (Cap.242) and the Finance Act of 1994/95.

Energy saving measures that also address Mitigation of climate change in Kenya has benefited from some local industrial initiatives. They include fuel switch, modification of combustion processes, energy efficiency, and the growing of commercial forests.

The private sector will be facilitated to access new sources of funds such as CDM to comply with the requirements of the Environmental Management and Coordination Act.

Forestry: Forestry ecosystems represent an important component in carbon sequestration and conservation. Forests can store from 20-100 times more carbon than other

vegetation on the same land area, or around 30-60 tons of carbon per hectare. The forestry sector is a major contributor of GHG exchanges in Kenya.

Large-scale deforestation can lead to dangerous emissions of greenhouse gases into the atmosphere. It is only through planned land-use changes, proper forestry activities and policies that a greenhouse gas retention level can be reached that will ensure low level of emission to the atmosphere.

Policies that have direct bearing on land-use change and forest development include the national energy policy, the national food policy, policy of economic management for renewed growth and the National Environment Action Plan. These policies have been strengthened by the Environmental Management and Coordination Act of 1999.

Two mitigation options are being considered while others are being implemented. Two mitigation options have been proposed in the forest sector namely: Reforestation and protection. The benefits of reforestation for Kenya are much higher than those for protection. In addition, proper planning and clear definition of land use policy including classification of forests and their management strategies should lead to sustainable development and enhanced carbon storage. Furthermore, there is a need to undertake research in various agro-ecological zones with good tree planting culture with a view to developing strategies for collecting data on trees planted in private and trust (communal) lands, establishing biomass productivity tables for at least 10 widely planted tree species for use in estimating carbon sequestration levels, and developing procedures for enhancing community participation in establishment, management and use of forest resources.

Waste Management: In Kenya, waste generation has increased considerably due to rapid increase in human population, industrial development, and consumption patterns. Socio-economic activities have since the 1960s increased the volume and complexity of waste with organic waste constituting by far, the largest portion. Organic wastes generate most of the greenhouse gases emitted into the atmosphere.

Initiatives have been developed for managing waste. These initiatives are intended to improve cleanliness and health, but have some indirect bearing on abating GHG emission.

There are also economic and environmental benefits to these initiatives.

Promotion of waste reuse and recycling and raising public awareness should have a positive impact in the mitigation of greenhouse gases as most of the waste is organic which when it degrades, produces CH_4 and CO_2. Inadequate resources for provision of equipment, logistics and also raising public awareness, and building human capacity is hampering sustainable waste management. This results in low levels of reuse/recycling as well as waste generation reduction.

Future initiatives should promote economically sound practices for managing municipal wastes that take advantage of waste reuse and recycling thus abating emissions of GHGs. Currently, there are a number of recycling activities and composting of various waste streams that only need to be promoted to minimize waste at source.

2.16 Vulnerability and Adaptation

Agriculture: Agriculture has been the mainstay of the Kenyan economy, but its contribution to GDP declined from 37% in 1964 to 24.5% in 1999. It is the basis for food security, for economic growth, employment creation and foreign exchange generation. Most Kenyan industrial and manufacturing firms are agro-based. The development strategy depends on agriculture and industry for faster economic growth. Most of the agricultural production in Kenya comprises mixed farming – raising of crops and livestock. It accounts for 60% of foreign exchange earnings and provides raw materials for industries. Agricultural production systems in the high potential areas are more intensive as compared to the semi-arid areas. Maize is the staple food crop, while the dry bean is the most important legume crop. Coffee, tea and sugarcane are the major commercial crops.

Livestock production falls under two systems: diary, predominantly in the high potential areas and pastoral in the semi-arid areas.

Climate change projections to the year 2030 indicate increasing temperature changes with doubling of CO_2 levels from baseline scenarios resulting into a decline in precipitation in the semi-arid areas. This will lead to reduction in maize yields. The impact of climate change on

livestock would be shortage of forage, increased disease incidences and breakdown of marketing infrastructure.

Adaptation options in the agriculture sector would include: development of early maturing and high yielding crop varieties and adaptation of agricultural technologies from analogue environments.

Water: Kenya is fairly endowed with water in the form of rainfall, ground water, river flows, lakes and oceans. The country is divided into five main drainage basins. Hydrological models have been used to estimate the impact of climate change in several water sub-sectors, viz, soil moisture, ground water recharge, river runoff, lakes wetlands, water quality and mountain glaciers. Projections indicate that the region from Lake Victoria to the central highlands east of the Rift Valley will experience mild increase in rainfall. The highest increments of annual rainfall were observed to be in the areas in the vicinity of Mt. Elgon.

Increasing human population will exert pressure on Kenya's hydrological systems and water resources. This will be further compounded by climate change impacts. The ability to adapt to variability and change will be affected by a range of institutional, technological and cultural factors at national, regional and local levels.

Aquatic and Marine Resources: The coastal environment and habitats support some of the most diverse resources in the country. These include mangrove forests, coral reefs, sea grass beds, and rocky and sandy shores. Fisheries activities are pivotal to the household economies of riparian communities. The bulk of the country's fisheries resources come from Lake Victoria, while the aesthetic value of coastal resources contributes significantly to the national economy, mainly through tourism.

Climate Change is expected to alter the physical, biophysical and biochemical characteristics of marine eco-systems in Kenya. The Kenyan coast is regarded as one of the most vulnerable to sea level rise. Agriculture, infrastructure and tourism in this area are considered to be under threat.

Energy: In Kenya, energy is harvested from a variety of renewable and non-removable resources such as hydropower, biomass, solar, wind, and petroleum and geothermal. Petroleum fuel is the major source of energy used by

commercial and industrial establishments. Electricity is the third most used source of energy in Kenya after fuel-wood and petroleum products, but is second to petroleum fuel as a source of commercial energy. About 80% of Kenya's population depends on woodfuel for its domestic energy needs and by the rural informal industries such as brick making, pottery, jaggery, manufacturing and food processing. The scarcity of fuel-wood and the impact of its escalating prices are acute at the household level because of poverty and limited alternatives.

The most significant impact of climate change on energy will be by extreme weather events such as those caused by the El nino-La nina phenomenon. Vulnerability in this sector will be manifest in changes in river flows and increased rates of depletion of biomass.

Health: Climate and weather variability affect natural processes, which in turn affect human health. One of the major impacts will be increased incidences of vector and water borne diseases and poor nutrition.

Development of preventive mechanisms for vector and water borne diseases, surveillance for epidemics that follow episodic weather events and improvement of infrastructure in the health sector are among key policy issues to be pursued.

Socio Economic Context: Kenya's Human Development Index (HDI) estimated the socio-economic development progress of the nation at 0.539 with variations across provinces and districts. Such disparities are reflected in differences in regional resource base, infrastructure development and life opportunities.

Table 2-2: Human Development Index

Province	Life Expectancy (1999)	Adult Literacy (1999)	Annual Income per Capital Kshs. (1999)	Life Expectancy index	Education Index	GDP Index	HDI Value
Kenya	54.7	70.9	16,406	0.495	0.642	0.482	0.539
Nairobi	61.6	82.2	78,644	0.610	0.756	0.983	0.783
Central	63.7	83.9	17,829	0.645	0.829	0.339	0.604
Coast	51.5	62.8	18,840	0.408	0.595	0.363	0.467
Eastern	62.3	66.5	15,131	0.443	0.687	0.268	0.525
Rift Valley	61.9	72.6	15,251	0.558	0.652	0.271	0.510
Nyanza	45.7	70.90	14,169	0.345	0.736	0.239	0.440
Western	52.4	64.2	11,191	0.457	0.460	0.324	0.413
North Eastern	52.4	64.2	17,212	0.457	0.460	0.324	0.413

The components of HDI which are indicators of vulnerability, vary widely across the regions with large parts of the country falling in the low human development category and compare with LDCs. Comparing the indices for Nairobi and the rest of the country, it is evident that measures to enhance growth of income should be integrated with other national efforts promoting human development. Provision of education and life-prolonging services such as good health care are crucial in human development in the country.

Human Poverty Index

Kenya's Human Poverty Index (HPI) value has steadily risen from 26.1% in 1997 to 34.5% in 2001. This reflects in part a fall in life expectancy in the country. When looked at in absolute numbers poverty is a serious national development challenge the Human Poverty Index shows that the level of deprivation in the country is high.

Table 2-3: Human Poverty Index

Province	Population not expected to survive beyond age 40 (% of total population)	Adult Literacy rate	People access to: Clean Water	Without Health care	Under-weight children under age 5	HPI %
Kenya	34.0	26.4	46.4	51.0	26.4	34.5
Nairobi	40.0	17.8	34.0	45.0	16.3	32.4
Central	31.0	16.1	46.0	51.0	15.7	30.7
Coast	36.0	37.2	28.4	62.0	27.3	37.5
Eastern	31.0	33.5	46.6	75.2	27.8	39.9
Rift Valley	27.0	27.4	59.0	62.0	27.4	36.8
Nyanza	46.0	29.1	64.0	69.4	29.1	44.3
Western	42.0	25.4	61.6	58.8	25.4	41.1
North Eastern	45.0	35.8	34.2	89.0	35.8	44.8

2.17 Technology Needs

The technology needs for Kenya are enormous as the country has yet to achieve the poverty eradication targets set out in the NPEP (6.6%), while growth rates of above 7% are required to achieve the industrial transformation goals by 2020.

Utilisation of technology inputs to transform the economy will be of crucial importance to the country.

The country's basic needs can be summarized as follows: -

- Adequate food supply and sustainable land use management.
- High quality of energy services.
- Rapid industrialization of basic commodities.
- Adequate supply of economic, education and social services.
- Adequate housing and transportation infrastructure.

Achieving these basic needs will require significant technology imports. This task will and has been made more difficult by adverse developments in the world economy, changing priorities in external donor support and foreign direct investment in favour of the newly emerging economies.

Other contributing factors include the increasingly erratic climate variability and change, and regional insecurity and global competition.

These constraints notwithstanding there are several climate-friendly ESTs which could be used to provide these basic needs and assist the country in being more competitive.

These technologies include: -

Energy Extraction And Supply Technologies

- Power plant efficiency improvement
- Fuel switching
- Renewable energy development
- Clean and efficient development of fossil fuels

Energy Demand Technologies

- Energy efficient appliances.
- Promotion of energy efficiency.
- Decentralised energy systems.

Transportation Technologies

- New – energy efficient technologies
- Alternative fuels
- Improved maintenance
- Improved fuel management
- Promotion of public transportation
- Import restrictions
- Transportation infrastructure

Infrastructural Technologies

- Improved settlements and transport infrastructure.

Agricultural Technologies

- Improved agricultural management
- Improved livestock management
- Improved rice cultivation
- Increased efficiency in application of fertilizer
- New crop varieties
- Improved water management

Forest Technologies

- Afforestation and reforestation
- Improved forest management

- Improved logging and wood processing techniques

Industrial Practices

- Promotion of less energy intensive industry and practices.

Cogeneration

- Fuel switching
- Improved processes
- Material shifting

Waste Management Technologies

- Waste recycling
- Composting

There is also need for technologies to participate in Research and Systematic Observation

2.18 Institutions for Technology Transfer

Several institutions are needed for this and as what is the current practice as elaborated in the sectoral contributions to mitigation technologies. These include government ministries that are responsible for policy development and implementation including that of coordination and monitoring, private sector institutions involved in the manufacturing and dissemination of technologies, and Research and Development institutes involved in innovation and product modification. Also needed are institutes to deal with technology needs assessment and incubation. These two initiatives if carried out well would make the country an active participant in the field of technology transfer.

Barriers to Technology Transfer

These can be classified as technological, institutional, information, financial and market barriers, absence of an explicit policy on technology development (acquisition of skills and knowledge from external sources and upgrading of indigenous skills).

Technology barriers

A critical mass of human capital with the needed technical knowledge and skills is crucial for technology development and transfer. Without this then the normal engineering procedures for testing, commissioning and supporting equipment purchases will be lacking. This contributes to poor maintenance programmes leading to technologies appearing dysfunctional.

Lack of appropriate standards based on local conditions is another obstacle. There are institutions expected to perform these functions but with inadequate resource and manpower provision their performance is eroded significantly leading to poor technology sourcing, selection and assessment.

Institutional barriers

While Kenya has an institute responsible for development and use of technology, it suffers from poor integration with other energy institutions so as to increase their effectiveness.

Information barriers

Lack of technological awareness is an important barrier to the widespread use of technological solutions in the country. This is expensive as it leads to wrong selection and application of technology. Even where there are technically competent personnel, they lack access to global information, resulting in sub-optional choices leading to poor design of projects. Lack of non-technical information such as banking and insurance information are crucial for investment decisions and impede technological program.

Financial barriers

There has been a low perception of the economy leading to higher discount rates which in turn restricts investments. The poor performance of the economy has restricted the country's capacity to access external finance for projects and other financial needs, adversely affecting technology development. This also limits the participation of local entrepreneurs wishing to collaborate with external partners.

Conclusions

The country needs large technology inputs to improve the quality of life of its population.

These inputs must be a combination of technology developed locally utilizing local and other skills and large-scale technologies imports.

To attract this technology flow there is a great deal of effort required to develop the enabling environment for attracting foreign investments. This will require spending more on human resource training especially on high-level technology Research and Development.

The country should also encourage more FDI over ODA. This will foster technological growth.

There are several policies aimed at increasing the flow of climate-friendly technologies in the country but they are yet to surmount all the barriers mentioned above. Enhancing the flow of technology cannot be done through one institution but by cooperative effort with the Government playing a central role. International assistance can assist the country achieve the goal of development but local efforts are of greater importance.

CHAPTER THREE

3. ENERGY SECTOR

3.1 Overview of the Energy Sector

3.1.1 Introduction

Energy technology assessment is a comprehensive, rigorous analysis of all aspects of energy technology systems for meeting a particular end use or need. It is therefore an important component of energy planning geared to providing a set of the best technical options for meeting the identified energy needs. Kenya's broad objective of the energy policy is to ensure adequate and cost effective supply of energy to meet development needs while protecting and conserving the environment.

Rural households use candles and kerosene lamps for lighting and dry cells for radios and torches. Lead-acid batteries are also used to power dc electrical lights, TV sets and radios. These lead-acid car batteries are routinely recharged at distant local shopping centers where grid electricity or generator power is available.

Since 1973, the government has undertaken distribution of electricity in areas where the financial viability seems doubtful to the utility under a Rural Electrification Program (REP). The focus of the program is to supply power to agro-based and other small industries, shops, institutions, water supply and other public facilities. Individual households are encouraged to hook up to the supply if located within reach of an installed transformer.

Across Eastern Africa electrification of rural households and business through the grid covers a paltry approximately 0-3% of the rural population. This means that in a region of 15 million rural households, less than 2% have access to modern electricity. Since the inception of the Rural Electrification Programs (REP) more than 17 years, approximately 62,000 or 2% of rural households have been connected to grid power at a cost of USD 600 million. Major constraints to REPs have been: high capital costs, high revenue collection costs, low income from existing operations, insufficient generating capacity and high connection costs for scattered households. To improve access to electricity and modern energy services to rural households and businesses, a shift in rural electrification

towards the proliferation of decentralised power systems is essential.

Electrification on its own does not solve poverty problems in the rural areas. There is a need to integrate energy services in the rural areas with broader development initiatives, such as improvement of road infrastructure, health facilities, improvement of road infrastructure could facilitate a better delivery of energy services and other basic services, education and safety issues,

- Creating employment opportunities, so consumers can be empowered to pay their services,
- Improving socio-economic conditions for rural households, electrification programmes such as non-grid electrification do not suite everyone's needs and cannot be afforded by all the households, some remain too poor to afford the services and remain unelectrified.

The energy sector in Kenya is dominated by petroleum and electricity as the prime movers of the modern sector of the economy while wood fuel, provides energy needs of the small and medium level sector including rural communities and the urban poor. At the national level wood fuel and other biomass account for 68% of the total primary energy consumption, followed by petroleum at 22%, electricity at 9% and others at about 1%. Solar energy is also extensively used for drying.

Electricity, by virtue of its versatility is crucial to Kenya's economic growth. It is the most sought after energy service by the society and access to electricity is associated with rising or high quality of life. However, its consumption in Kenya is extremely low at 121/kilowatt-hours (kWh) per capita.

3.1.2 Institutional Arrangements

The Government's activities in the power sub-sector are limited to formulation and articulation of policies through which it provides an enabling environment to all economic operators and other stakeholders, training of manpower, preparation of the country's least Cost Electric Power Development Plan (LCPDP), implementation of the rural electrification programme and to a large extent mobilisation of financial resources for system expansion.

The Electricity Regulatory Board (ERB) is an autonomous, independent sub-sector regulator, established in 1998 under the Electric Power Act to, inter alia, set review and

adjust consumer tariffs, approve power purchase agreement, promote competition in the sub-sector where feasible, resolve consumer complaints and enforce environmental health and safety regulations.

KenGen, a state owned company, and KPLC in which state interest stands at 51% of the equity are the principle players in the power sub-sector. KPLC has a virtual monopoly in power transmission, distribution and supply. Furthermore, KPLC as the only licensed Public Electricity Supplier has energy purchases contracts with Independent Power Producers (IPPs) and KenGen. KenGen accounts for more than 81.8% of the total installed capacity, the private sector for 16.1% and the Government under the Rural Electrification Programme for 0.4%. The two parastatals: KenGen and KPLC have the responsibility of raising funds needed for system expansion with and without state guarantees.

The involvement of the private sector in commercial power generation is a recent development since power generation was only liberalized in 1996. Four IPPs with a combined installed capacity of 187 MW are currently in operation. Each IPP is responsible for the operation and maintenance of its own power plant. The role of the private sector is expected to grow over time in power generation, distribution and supply. However, the transmission network will remain a monopoly providing power wheeling access to electric power producers, large retail consumers, other bulk power suppliers and distribution companies.

Direct Government involvement in the petroleum industry is in the oil refinery where it co-owns the Kenya Petroleum Refineries Ltd (KPRL) with three private companies (Shell, Beyond Petroleum and Caltex) on a 50-50% equity basis and oil storage facilities at Kipevu, capable of holding 1.5 million barrels. The storage facilities are available to all licensed importers at a monthly storage fee of US$2 per kilolitre. The Government through the Kenya Pipeline Company (KPC), in which it has 100% equity, owns a petroleum pipeline that runs from Mombasa to Nairobi and Western Kenya with terminals in Nakuru, Eldoret and Kisumu. The Government is also the sole owner of the National Oil Corporation of Kenya (NOCK), which is involved in oil supply and distribution. NOCK also undertakes oil exploration on behalf of the Government. The Kenya Railways Corporation (KR), a state owned company is a key transporter of petroleum fuels, primarily LPG, heavy diesel and fuel oil from Mombasa to Nairobi and other up-country demand centers. It also transports kerosene, petrol and

automotive gas oil, principally to areas not served by the petroleum pipeline.

Regulatory functions in the petroleum sector are shared amongst various players including the Ministry of Energy, Provincial Administration and Local Authorities. The Petroleum Institution of East Africa (PIEA), which is a voluntary membership institution, patronized by the major oil companies plays a key role in capacity building and awareness creation.

The private sector has an extensive network of distribution and marketing outlets in different parts of the country and accounts for about a 99.4% of the total markets sales of petroleum fuels. Seven oil companies, Shell, BP, Total, Mobil, Kenol, Kobil and Caltex account for about 85% of the total sales. Several small companies that have continued to join the market since liberalization of the industry in October 1994 account for the other 14%. Collectively, private sector companies have installed about 1000 filling and service stations countrywide. Out of these companies only two, Total and Kenol are listed on the Nairobi Stock Exchange. NOCK, on the other hand has seen its market share decline from about 2% in 2000 to about 0.6% in 2003 and thus failed to live to the original Government objective of using the company to regulate petroleum market price through competition, following the deregulation of the industry in 1994.

3.1.3 Kenya's Energy Sources

Energy demand in Kenya is met from four broad sources. These are woodfuel, petroleum, electricity and other renewable energy sources. Woodfuel is the largest form of energy consumed in the country, accounting for about 68% of the national total. Petroleum is the next most important accounting for 22% followed by electricity 9%. The other renewable forms of energy including solar, wind and micro hydropower account for about 1%.

3.1.4 Biomass

Biomass energy resources are derived from forests formations such as closed forests, woodlands, bush lands, grasslands, farmlands, plantations and agricultural and industrial residues. These resources include wood fuels (fuel wood and charcoal) and agricultural residues. Biomass fuels are the most important source of primary energy in

Kenya with wood fuel consumption accounting for over 68% of the total primary energy consumption.

Only 2% of Kenya's land area is covered by forest, which produce about 45% of the biomass energy resources including wood wastes. The balance is derived from farmlands in the form of woody biomass as well as crop and animal residues. There have been two studies on biomass energy undertaken by the Ministry of Energy, one in 1980 and the other in 2000 respectively. These despite being two decades apart reflected widening gap between supply and demand for wood fuel and recommended policy interventions to redress this challenge.

3.1.5 Fossil Fuels

Petroleum fuels are the most important source of commercial energy in Kenya, and are mainly used in the transport, commercial and industrial sectors. In 2002 the consumption of petroleum fuels in Kenya was 2.3 million TOE, equivalent to per capita consumption of 74 Kilogrammes, a figure that is indeed low even by the standards of developing economies. This low consumption level has been due to economic growth stagnation and over dependence on rain-fed agriculture. Coal is exclusively used in the industrial sector, particularly in the cement industry for process heat. The level of consumption in 2002 was 99,000 TOE.

Table 3-1: National Energy Demand by Energy Type

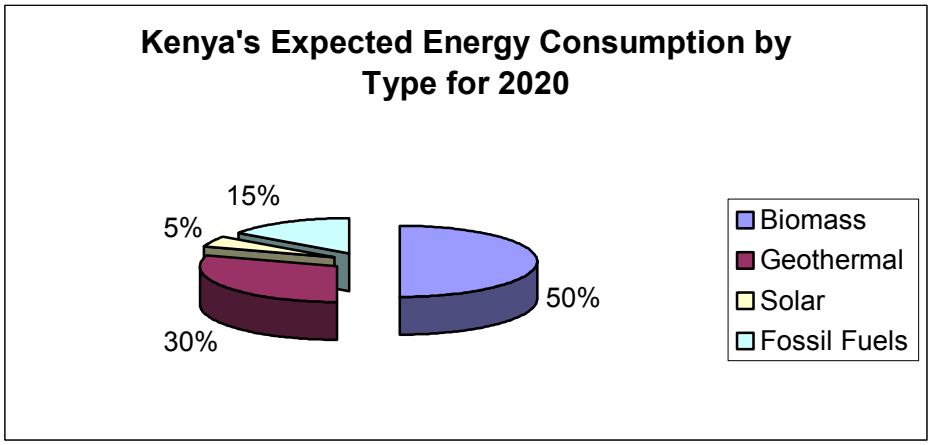
Energy Type	Total Gigajoules (000) Percentage for all sectors for all sectors	
Firewood	251,680	36%
Charcoal	264,104	39%
Industrial Wood	1,747	0%
Wood wastes	3,525	1%
Farm Residue	37,013	5%
Petroleum	124,960	18%
Electricity	9,834	1%
Total	692,863	100%

3.1.6 Electrical Power and Energy Projections

With the anticipated economic recovery, electricity demand is projected to grow from 4900GWh in 2001/02 to 7900GwH 55in 2010/11, representing an annual average growth rate of

5.4%. This translates to about a 1400MW peak demand by 2010/11, from about 750MW currently, corresponding to an effective generating capacity of about 1700MW.

Fig 3.1 Kenya's Expected Energy consumption by Type for 2020



Challenges

The electricity sub-sector faces a number of challenges, key among them including limited capacity for resource mobilisation, low access to electricity services, high consumer tariffs and environmental concerns. These are discussed below.

Resource Mobilisation

The government has in the past sought and obtained development assistance from external sources, particularly from development partners, on concessionary terms to implement power system expansion in consonance with rising demand for electricity. However, since the end of the cold war, this external source of funding has continued to dwindle thereby impacting adversely on the Country's ability to implement planned development projects. The drop in funding was largely due to the emphasis by the development partners on the need to promote private sector involvement in the provision of commercial infrastructure. Furthermore, the liberalization of power generation in 1996 has also not attracted significant private sector interest and despite the small number of bidders for the projects implemented or under implementation by the IPPs, serious delays had been encountered in concluding negotiations with successful IPPs. This further worsened generation capacity shortfalls in 2000, leading to massive power rationing and attendant devastation of the economy. Given this situation,

there is therefore a need to address issues of concern to the IPPs, where prudently possible but not at any cost.

Moreover, due to the inability to mobilise requisite funding for undertaking pre-feasibility and feasibility studies of the Country's hydro potential and for geothermal resource assessment, the country risks being overly dependant on oil-fired generation to meet projected growth in demand for electricity. It is therefore critical to mobilise needed resources to undertake these assessments if both hydro and geothermal power projects are to play a significant role in economic merit order ranking in Kenya's electric power generation which emphasizes selection of projects based on least cost development criteria.

Despite the reforms undertaken in electricity tariffs and rightsizing of personnel establishments, KPLC, which is the sole distributor of commercial electricity, has continued to manifest weak financial performance, which has impeded access to domestic and international, money markets for the needed system reinforcement and expansion. Moreover such performance has largely influenced the demand for and degree of payment security dismal guarantee from lenders and IPPs, further aggravating the already weak financial situation of KPLC. There is therefore need to undertake further reforms to create an appropriate power market structure capable of attracting both domestic foreign investments, at competitive costs.

Accessibility to Electricity at an Affordable Cost

A developing economy such as Kenya requires electricity to effect a prudent pace of social transformation and economic development. Access to affordable electricity services by all sectors of the economy is therefore, crucial. Access to competitively priced electricity services is particularly critical for manufacturers and services to enable our producers compete favourably on the international market, other factors being equal. However, access to affordable electricity services has been constrained by a combination of low consumer incomes and high electricity tariffs. Furthermore, the rate of electrification currently at about 15% of the population has remained low due to the high cost of consumer connection and network expansion particularly in rural and among the urban poor. In the rural areas, where the access rate is about 4% the scattered nature of human settlements further escalates the cost of accessibility. A new policy strategy is therefore needed to redress the challenges.

Current High Consumer Tariffs

The crowding of power generation and transmission projects following the lifting of donor aid embargo to the energy sector in the second half of the 1990s has contributed to high consumer tariffs; as have operational inefficiencies by KPLC and the high generation tariffs charged by IPPs. High consumer tariffs have in turn affected affordability and hence accessibility of electricity by consumers thus leading to the marginalisation of low-income consumers including some small scale commercial and industrial enterprises. As high electricity tariffs are a disincentive to social and economic development there is need to critically develop strategies for reducing tariffs to spur growth. Such strategies should include cost effective operation and maintenance of generation and distribution companies, implementation of projects based on least cost criteria, prudent corporate governance, review of indirect taxes levied on power generation, transmission, distribution and supply equipment, plant and machinery, spare parts and related accessories; and implementation of generation and transmission projects on schedule to avoid undue demand for tariff increase to finance the projects.

Rural Electrification

The rural electrification programme was started in 1973 as part of the basic infrastructure to stimulate socio-economic growth, stem rural-urban migration through creation of social amenities and employment opportunities at close proximities to the rural population and thus uplifting the quality of life in the rural areas. However, the rate of penetration has been slow with only 87,175 directly metered consumers having benefited from the programme by June 2003. The low penetration level is attributed to past mismanagement of financial resources, high cost of network extension, low consumer densities and the scattered nature of the human settlements in rural Kenya. In 2003, it cost more than KShs.1.2 million on average to construct a kilometre of an 11kV or 33kV line. Thus, the average coast of supplying a rural consumer was KShs.180,000, which is about seven times the national per capita income in 2002. Rural electrification schemes also incur higher operating cost per unit sold than the KPLC system sales. For example, over the period 1997/98 to 1990/00 the average cost of selling one unit of electricity under rural electrification programme was KShs.9.51 per kWh for the interconnected system as opposed to KShs.5.74 per

kWh for KPLC, while for the isolated programme schemes the cost was KShs.31.7 per kWh.

Despite this high cost, very few of those who have been connected in rural market centres have made economic use of electricity. This has been attributed to poor entrepreneurship, high poverty incidence that nationally stands at about 56% of total population. Lack of awareness on the potential for electricity to stimulate income-generating activities and lack of innovative and appropriate financing schemes to promote commercial and industrial enterprises including irrigated agriculture and fisheries. Because of high maintenance and operating losses relative to the tariff charged, 80% of the Rural Electrification Programmes revenue from sales and the 5% levy introduced in August, 1998 is used to finance net operating loses, thus leaving very little funds for system expansion. For this reason, the large numbers of projects submitted every year for funding are not implemented. There is therefore urgent need to address challenges of limited funding in order to increase the rate of rural electrification to a penetration target of at least 40% of the rural population by 2020 from the current 4%. There is also need to explore alternative innovative mechanisms for funding the Rural Electrification Programme and to improve the efficiency of operating and maintaining the system in order to release funds for system expansion of electrification through on and off-grid systems.

The current institutional arrangements for implementing rural electrification are unsatisfactory. There is no fully-fledged government agency specifically dealing with rural electrification planning, resource mobilisation, system expansion and operation. Currently an inter-ministerial committee including KPLC, which also doubles up as the implementing contractor, is running the Rural Electrification Programme. Moreover, due to the lack of such an institution rural electrification planning is not properly incorporated into integrated energy and development planning, despite explicit policy statements in the past economic Sessional Papers and Development Plans. It is therefore critical to establish a Rural Electrification Agency, to be in charge of the programme.

Environmental Concerns

The construction and operation of electricity projects, including power plants as well as the transmission and distribution networks, have direct impacts on the quality

of the environment either by the emission of pollutants or by changing the ecological systems. The degree of pollution and other ecological impacts are dependant upon the nature of the technology in use as well as the size and the general location of the plant. Environmental, health and safety regulations require that mitigating measures be put in place to minimise the adverse impacts of such projects. Therefore, comprehensive environmental impact assessment are conducted for all projects prior to their implementation to ascertain the level of potential environmental damages, the required mitigation measures as well as the associated costs.

Geothermal and hydroelectric power projects are known to have relatively less environmental impacts than fossil fired plants. However, not much attention has hitherto been given to the environmental impacts of the distribution grid expansion and therefore need to address the challenge striking a balance between the environmental concerns posed by the distribution grid expansion one hand and on the other, economic development, access and affordability

3.1.7 Conclusion

Energy is pivotal for economic and social development. While lack of access to energy services constitutes a major obstacle to sustainable development, its improved access to the poorer sections of the Kenyan population would contribute directly to poverty alleviation. Therefore access to affordable and appropriate energy services must and should grow significantly to improve the living standards of the country's growing population. The development and promotion of renewable energy resources in the country targeted country targeted at rural communities, stands to provide sustainable alternative energy options to problems related to deforestation, desertification, environmental pollution, greenhouse gas emission, global warming, climate change and over dependence on fossil fuels.

Its clear that that there is a significant market for RE technologies in many rural and urban areas of the country. Over the last two decades, promoters of the technologies have laid the foundations for the market to develop in many different ways, with valuable lessons learned and formulae for success documented.

Renewable energy therefore present a viable solution for not only mitigating global warming, but presents as well a

viable solution for provision of modern energy services to millions of un-serviced Kenyan households. Sustainable RE energy provision in Kenya would therefore only be possible through integrated technology, policy, finance and human capacity building approach. Players in the sector must therefore integrate these virtues in their program design if the destined impacts are to be realized.

The United Nations Framework Convention on Climate Change (UNFCCC) recognizes the vital role of technology in both adaptation to, and mitigation of the adverse impacts of climate change. In that regard, the concept of Environmentally Sound Technology (EST) looms into relevance. Thus the issue of technology transfer, the associated perceived barriers and the need to undertake national energy technology needs inventory are salient issue of on-going global climate change discussions. The energy activities contribute significantly to the global emission of greenhouse gases, which are responsible for global warming problem. Energy technology needs assessment is an important step in identifying the performance characteristics of current technologies, in order to ultimately enable the transfer of environmentally sound technologies.

Energy Efficiency (EE) focuses on modifications in end-use technology (e.g. lighting). Energy Conservation focuses on changing energy consumption use patterns through educational projects and the use of time-of-day tariffs. Many projects involve a combination of both energy efficiency and energy conservation measures that can result in low and/or no-cost climate change mitigation options. The level (and cost) of reduction is dependent on the source of electricity. If the electricity were generated by a fossil fuel (e.g., coal, oil, natural gas), then the reduced demand would translate into less generation and reduced GHG emissions. However, the supply and corresponding emissions response is not always straightforward. Reduced electricity demand could cause a price adjustment and a "rebound effect" where the reduced demand is offset by increased demand elsewhere on the system so there is no net change in generation or GHG emissions, or there is realignment in the sources of generation, so that even with reduced electricity demand lower GHG emissions may not be realized.

Renewable energy and energy efficiency are often presented as means of achieving sustainable energy supply. While the commercial infrastructure for RE is progressively

developing and being embraced, little progress is being made on the energy management front. Energy efficiency unlike energy conservation is a relatively new concept. Whereas energy conservation in simple terms means cutting down on energy use usually at the expense of convenience and comfort, energy efficiency means getting the full benefit of an energy service while using considerably less energy. Technology advances are propelling energy efficiency in energy conversion systems, end use appliances and associated control systems enabling tasks and processes to be accomplished with drastically less energy inputs.

Lighting is the most common and widely used energy end use application in households and institutions. Efficient lighting retrofits always pay back for themselves within a year or less. Energy efficient lighting is becoming mainstream with fluorescent and Compact Fluorescent Lamps (CFL) being readily available and increasingly affordable.

3.2 Renewable Energy Technologies

3.2.1 Introduction

In this section, an overview to the Renewable Energy Scenario and potentials in Kenya are given through highlights on Wind Energy, Solar PV, Solar Thermal, Solar Water Heating, Geothermal, and Energy Efficiency.

Kenya is endowed with significant amounts of alternative energy sources, which, inter alia, include solar, wind, and small hydropower. Others include power alcohol, biogas and municipal waste energy. However, only solar, wind and small hydros are currently harnessed in relatively large scale for use in Kenya. Renewable Energy (RE) is most often defined to be energy derived from inexhaustible sources—the sun, the wind, and the Earth. In addition, renewable energy options often include the use of wastes to produce high valued and useful energy. The use of renewable energy has the advantage of producing little or no carbon emissions. Wind power, photovoltaics, biomass derived from sources that are continuously replenished, and hydroelectricity has no net carbon emissions.

Although energy derived from wastes can emit carbon, such emissions are usually not more than for natural gas-based systems. As a result, using renewable energy in lieu of fossil-based systems would significantly lower carbon (and GHG) emissions. Approximately 30 quadrillion Btus of renewable energy are currently consumed throughout the

world. This represents approximately 8% of world energy consumption. Although the large majority of renewable energy consumption is from large hydroelectric sources (and in some countries, biomass), use of biomass, wind and photovoltaics is growing rapidly. For example, it is estimated that, for each of the last few years, more than 1,200 MW of new wind generating capacity have been installed throughout the world.

3.2.2 Solar Energy Technologies

This is the energy radiated from the nuclear fusion from the sun's hot interior part at a constant rate estimated at 4 $x10^{26}$ W. To make use of this energy it must be converted into three useful forms thus, chemical, heat (thermal) or electrical. Solar energy stored in chemical form forms the bulk of the world most utilized energy (biomass), stored in all plants through photosynthesis. Solar thermal devices transform solar energy into that which is used for drying, water and space heating, cooking and distilling water. While the electric devices transform solar energy into electricity for lighting, pumping water, powering radios, etc.

Solar electricity is the electric power generated from sunlight using devices called *solar cell modules*. The technology is gaining popularity in Kenya as prices of other electric energy sources rises. Solar electricity can replace small applications of petroleum-fuelled generators, grid power and dry cell batteries. This technology is spreading rapidly to rural areas where there is a growing interest for its applications. Solar electric systems are being sold to end users in Kenya through a competitive and growing free market network that includes more than 10 import and manufacturing companies, as well as hundreds of vendors, installers, and after-sales service providers. On a per capita basis, Kenya has one of the largest and most dynamic markets for solar energy products in the developing world. Most of this activity is in the market for household solar electric systems, with cumulative sales in excess of 200,000 units and current sales of about 20,000 systems per year. During the 1990s solar electricity emerged as one of the main alternatives to the electrical grid for household rural power1, and sales growth in the solar industry - 18% from 1991-2001 - was higher than the rate of new grid based rural electricity connections (11% over the same period) [Hankins, 2000a; Duke, et al., 2000; ESDA, 2003; Economic Survey of Kenya, 1991-2002]. While there is little doubt about the size and relatively rapid growth of the Kenya solar market, there are a number of debates about how to

interpret its significance. Solar advocates commonly make claims about the environmental, rural productivity, and poverty alleviation benefits of solar electrification [e.g. Kaufmann, et al., 2000; Ybema, et al., 2000; Martinot, et al., 2002].

However, some critics challenge these claims contending that the environmental benefits of solar electrification in rural developing country contexts are minimal, productive uses are few and far between, and that in the absence of large subsidies solar sales are primarily to the rural elite rather than the rural poor. These authors argue that cost of solar electrification is too high relative to its environmental and development benefits to merit significant international support, and that donor funds supporting solar market development should instead be diverted elsewhere [e.g. Karekezi and Kithyoma, 2002; Villavicencio, 2002; Leach, 2001; Inverson, 1996].

Solar electrification is often associated with E.F. Schumacher's appropriate technology movement, but findings indicate that the social uses of solar electricity are far removed from his classic "small is beautiful" vision of building small scale alternatives to global capitalism [Schumacher, 1973; Kitching, 1989]. Instead, solar electricity is widely used in rural Kenya to power wireless communications technologies that are linked to processes of economic integration and greater rural-urban connectivity. Nonetheless, while solar electrification is unquestionably beneficial to corporate TV and radio advertisers seeking to expand consumer goods markets to small towns and rural areas as well as to rural residents who wish to increase their urban connections, solar electrification and the use of wireless communications technologies should not be described simply as fitting into a broader pattern of "globalization" that is bringing rural Kenya into its embrace.

a) Kenya's PV Market

Kenyan PV market remains an excellent showcase that has demonstrated to the world that rural population willingness to pay for solar electricity is often underestimated. To date more than 3.2 MW of amorphous and crystalline silicon have been installed and the PV industry is worth US$ 6 million new installations per year (500kW/year).

Table 3-2: Potential For Rural Electrification and Contribution by PV in Eastern Africa

Country	Un-electrified Rural HHs (Million)	Rural Electrification	Annual PV (kWp/year)
Eritrea	0.5	~3%	<50
Ethiopia	7	<1%	<50
Kenya	3.5	<3%	>500
Tanzania	2.2	~1%	<50
Uganda	2.5	<1%	>100

Source: ESDA, 2003. Excludes small businesses

The demand for PV has grown exponentially since the mid 1980's, when Kenyan entrepreneurs realized that solar electricity could meet rural electric power demands for domestic use, often at lower cost than grid connections, generators and batteries. The market grew as rural-based artisans formed business agreements with urban solar companies based in Nairobi, thereby increasing the outreach and accessibility to PV equipment.

b) Photovoltaics (PV)

There are five common applications of solar PV electricity in the Kenya especially in the rural areas with no grid connection. These are:

- Solar Homes Systems (SHS) - providing households lights, televisions, cassette's players and small appliances. This forms the bulk market for Photovoltaics in the country
- Small industries and institutions - schools and small business in rural areas use solar electricity to power lights, sewing machines, calculators, light tools (drills, saving machines), calculators, typewriters, and security systems
- Telecommunications - as telecommunication systems are often installed in isolated areas with no grid connections, they often use stand-alone photovoltaics systems to power radios, telephone and even weather monitoring equipment in Kenya
- Health centre vaccine refrigeration and lighting - World Health Organisation has supported programmes that installs solar electric refrigerator and lighting in rural health centres

- Water pumping - In a number of sites in the country PV arrays connected to electric pumps are used to pump water from boreholes for domestic, irrigation and livestock use.

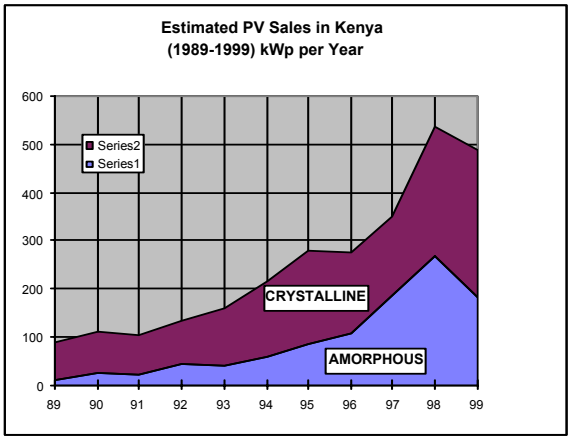
c) Market Development

Since the introduction of PV into the region, the local market has evolved through the following stages:

- *1985 – 89:* Transformation from donor driven to commercial market. SHS market developed steadily. Over 90% of the modules sold were crystalline. General growth in PV sales was around 5-10% for this period. Typical systems used crystalline modules of about 40 Wp (Acker and Kammen, 1996).

- *1990 – 98*: 10-14 Wp amorphous silicon (a-Si) modules entered the market in 1989, capturing the majority of SHS sales within five years (van der Plas and Hankins, 1998). Since then, total a-Si sales in Kenya have increased dramatically, from 10 kWp in 1989 to 270 kWp in 1998. The relative percentage of complete system sales went on the decline, while the number of over-the-counter, customer-installed systems increased. The bulk of the a-Si modules go to one-module systems.

Fig.3.2: 1998 to date: Small a-Si systems still dominate the market (by numbers).



d) Market Status

Kenya is notable for having mobilized its local entrepreneurial skills in the development of the PV industry. PV dealers can be found in virtually all-major

towns across the country. Below are the salient characteristics of the market:

- All solar modules are imported. There is no local manufacture. These come with varying warranties.
- Mean system size stands at 25Wp with an average purchase expenditure of US$418.
- More than 50% of the systems use a-Si modules with a majority of the systems undersized for their loads.
- Over 90% of the a-Si systems do not use charge regulators.
- Over 90% of the systems use locally manufactured SLI or modified SLI ('solar') batteries.
- Of all the 'Solar and TV" batteries sold to rural Kenya, 30% are SLI, while 70% are modified automotive batteries. All battery manufacturers currently offer a one-year warranty.
- Over 85% of the systems power black and white TVs, 84% have lights, while 70% have radios/cassettes. Users are from a wide range of backgrounds, but most have regular incomes. A majority of the users buy systems to run black and white television sets, lights and radio together, as opposed to lights only.

e) Recent Projects

This section provides a brief review of some selected recent projects in solar energy:

ESMAP Solar Finance: in an effort to develop a sustainable financing mechanism to further assist the commercialisation of PV in the country, ESMAP through ESDA conducted a pilot Solar Finance Project (1997 - 99). The approach was based on the co-operation of a finance partner, credit group and a technical partner.

The objectives of the exercise were to: increase access of SHS through financing, spread-out up front costs, offer savings through bulk purchase to offset cost of credit and to use better equipment. Two approaches were used; K-REP, a rural development bank and the Co-operative Bank of Kenya. Each group used its standard existing system of disbursement. In total 70 systems of sizes ranging from 24 Wp to 60 Wp were installed. Costs varied between US$500 and 1,100.

The major problems encountered included cohesion among loan groups, changing preferences and local politics. Lack of technical capacity among local installers was evidenced by the low installation standards. The most notable

achievement was that the project was used to climb the learning curve and convince bank managers of its viability.

Solar for Schools Project: this is a solar awareness initiative implemented by Solarnet, a regional NGO. Off-grid rural boarding schools receive a 50% subsidy to install solar electric systems and endeavour to use as demonstration installation during school visiting days. To date 10 schools have supported and installations used as a reference to educate students, teachers and parents on the benefits of the solar and other RETs. A further 10 schools have been evaluated and are going ahead with the systems installation. Solarnet through Ashden Trust (UK) are in further advance stage to implement 15,000 USD Energy for Schools projects. Targeting broader renewable energy technology to boarding schools in a region in Kenya, the project will provide a two-year repayment credit to 18 schools.

Photovoltaic Market Transformation Initiative (PVMTI): this is a US$5 million initiative of the World Bank/ GEF aimed at transforming the commercial market. The arrangement requires a 1:1 leverage of funds for participating consortium (financial and technical partner). Minimum disbursements are US$500,000 per consortium. This favours the larger Nairobi based companies. To date, two proposals have been short-listed for financing and deals are about to be closed.

The KCB Solar Loan Scheme: launched in December 2001, the US$3 million KCB Solar Loan wholly financed by the bank targets homes, offices, businesses, schools and other institutions that do business with the bank. Under the scheme to be run by the East Africa's biggest bank, customers are financed to purchase SHS, SWH, solar refrigerators, water pumps and power backup systems for both their domestic and commercial consumption. The loan limits are US$2550 and 7650 for Individual businesses/institutions respectively. BP Solar through its local distributor Solagen will supply equipment, carry out installations, maintenance and provide technical support. The program design has been completed and target branches (over 100-spread countrywide) are rearing to go.

f) The way forward

To develop the market further, several approaches can be pursued. These include among others:

Support for small players (rural dealers and technicians): these constitute the majority and have the best contact with end users at the local level. Support should be mainly in terms of technical training (installation and maintenance).

Support to large players: even though these are few, they are the main importers of PV equipment to the country. This is the approach taken by PVMTI. It is anticipated that financing the large players would lead to improved volumes and reduced costs. But given the high business overheads in the country, this might prove to be futile at the consumer level. Raising leveraging funds is proving to be a problem for the local companies. To overcome this, it is recommended that the minimum disbursement be reduced so that many more businesses can afford and benefit from the scheme. However, this will put in a lot of logistical stress on PVMTI.

i) End-user Financing: by availing loans to end-users through cooperatives or organised loan groups, affordability of systems can be greatly increased. The cooperative movement in Kenya is very strong and is the most strategic entry point. This was proven during the ESMAP Solar Finance pilot.

ii) Development of equipment and installation standards: the government has finally seen the light and has put out a bid for standards development. The Kenya Bureau of Standards is also working towards this end. However a code of practice for technicians still needs to be developed while enforcement will be another tall order.

*Introduction of fee service payment for solar electricity in rural areas: e*nergy service companies (ESCOs) should be formed to provide electricity by installing and maintaining Solar Homes Systems in the rural areas with no grid lines. This will further make PV to be a key element in rural electrification. It would provide opportunity for international utilities and companies in the north to form partnership with local companies, which will hopefully see innovative and creative minds being applied to the desired rural energy development in Kenya.

iii) Solar Thermal

Unlike PV systems, which use sunlight to directly produce electricity, solar thermal systems generate electricity with heat from concentrated sunlight. Solar thermal collectors use mirrors and lenses to concentrate and focus

sunlight onto a receiver mounted at the system's focal point. The receiver absorbs and converts sunlight into heat. Both solar thermal technologies (cookers, dryers, water heaters) and solar electric technologies have been disseminated in Kenya as from the early 1980's by developing agencies. These technology dissemination and experiences are well documented.

iv) Solar Cooking: Solar Kitchen

Though has been widely used elsewhere, a local company based in Kenya is currently manufacturing and installing their 'flagship' technology. The solar kitchen is a technological breakthrough in solar cooking that makes it possible for cooking to be carried out indoors for communities of up to 500 persons. High temperature solar dish systems are a series of parabolic 'fixed - focus – tracking 'dish/collector configurations that represent the technological solution to high temperature solar applications. This arrangement allows the focus of the concentrated heat to be stationary throughout, and can therefore be situated indoors for cooking, water heating and commercial and industrial applications like steam raising and absorption refrigeration etc. in the power range of 2 - 24kW (thermal) in single systems applications. The designs have since evolved and now glass is the preferred reflecting surface, and the clock designs have been made more robust. With these developments, the company is now focused on the task of marketing and developing commercial high temperature solar dish applications for the Eastern Africa region.

v) Solar Water Heaters

Solar water heaters are among the simplest applications for direct solar energy transforming solar radiation to raise water temperatures. There is a great local need for hot water in hotels, industries, hospitals, schools and homes. As wood used for traditional water heating is in short supply, while boilers in many institutions are using polluting oil, and heating water with electricity is very expensive. Solar water heating is becoming popular in Kenya. Estimated 7000 solar water heaters in the country installed mainly by institutions (hotels, hospitals and colleges) and the upper urban market relieving the national grid of 20MW.

In most domestic scenarios, water heating constitutes over 50% of the power bill. Consumers are still not encouraged to heat their bathing water and swimming pools with solar. The initial costs of installing solar energy equipment are

high. Companies selling solar thermal equipments are still levied 15% duty and still charge 16% VAT. This has therefore limited the number of people that would acquire the technology.

3.2.3 Wind Energy Technologies

Wind energy has been used in Kenya primarily for water lifting since the beginning of the 19th century but its use declined with the advent of oil fired internal combustion engines, which are flexible and more convenient to use. However, with the rising cost of fuels, the exploitation of wind energy is becoming increasingly more attractive particularly in areas remote from the grid and oil supply outlets. To promote investment in wind energy generation, Ministry of Energy has recently completed the development of the National Wind Atlas. In addition, the Government is promoting the development of wind-diesel hybrid systems for electricity generation under rural electrification programme.

The kinetic energy of the wind can be used to drive a turbine for electricity generation (wind generators) or pump water (windmill). The use of wind machines as an energy source dates back in the turn of the century when European settlers installed them in missions, ranches and in the homesteads. These were mainly used for either pumping water for irrigation, domestic or livestock use. The American multibladed design was common and was installed around Nanyuki, Eldoret, Kitale, Rift Valley and a long the coast.

During the 1960s, when cheap oil became available, most windmills were replaced by diesel engines. After independence, spare parts became unavailable and few people had the skills to fix the machines. Besides, importing windmills became expensive, hence the use declined and many installed machines broke down or stopped working. The rise of fuel prices during the 1970s made diesel pumps much more expensive to run. This led to both rehabilitation of the stalled windmills and importation of new ones. At the same time the government and many developing agencies, churches, universities, volunteers and private companies started wind projects.

A limited number of wind generators for use in remote in remote missions, farms and rural health centres (i.e. Olesseus of capacity 1-5kW) have been installed and are working in various places in Kenya. There are to-date a number of well established companies (Kenital, Telesales,

Solagen, Chloride Oxide, Ecogen and Sollatek Ltd.) that import and sell small wind generators ranging from 300-1000W. Also KPLC had installed three large-scale (200kW) wind generators that are operational at Ngong and Marsabit.

Even though wind electric power generation is a mature technology and with good prospects for power generation in a number of sites in Kenya, its uptake has been very low. Similar to other RE in Kenya, wind energy technologies dissemination has been marked with low awareness, high up front cost and technical back up supportive as well as institutional and regulatory barriers. However wind energy studies carried out in Kenya by Chipeta, (1970) and Oludhe, (1987), showed that there are many places with wind speeds greater than 4m/s that would be of much significance to wind power utilisation.

Even though wind is an intermittent source, on a large grid it can contribute an estimated 15 to 20% of annual electricity production without special arrangements for storage, backup and load management. The amount of energy in wind speed is proportional to the cube of the wind speed. While wind speed varies over time, it generally follows daily and seasonal patterns. Utility-scale wind power plants require wind speeds of at least 13 mph (6 meters per second). A 10 kW turbine located in a moderate wind regime can generate an average of 30 kWh of power each day. For large-scale projects, 12 months of consistent observation and recording is recommended for assessing wind resources. Wind energy produces no GHG emissions.

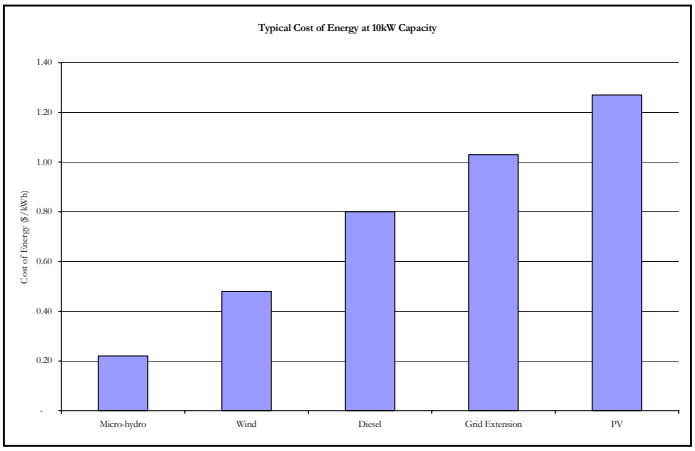
Wind Power Applications and Potential

Small wind systems can supply energy to households and businesses through hybrid or battery based systems. Rural households require modern energy for lighting, radio and TV, while businesses require electricity for lighting, entertainment, and refrigeration. The incidence of lead-acid battery charging stations and battery based systems in households and businesses provide a clear indication of the demand. Experience with wind systems has largely been in the water-pumping sector. Whereas water pumps can be found in the remotest parts of Africa, very few wind electric systems exist. These experiences have in the past been driven by settlers, missionaries and donors especially for health facilities, community and education centres. Though technically successful, the infrastructure to sustainably deliver and support them in the long term has not been developed.

Comparison of costs

The cost effectiveness of a wind system relative to a PV or genset cannot be determined solely by comparing the initial and annual operating costs. This is because these systems rely on different fuels that are available at different times. For example, a solar system without a battery can't work at night. Therefore a careful analysis of the energy needs is essential to design an optimal remote energy system. With reasonable assumptions concerning discount rates, capacity factors, and fuel costs, micro-hydro and wind turbines can have the lowest life cycle costs in locations where the resource is sufficient.

Fig. 3.3: A Least-Cost Option for Small Power: Typical Costs of Energy at 10 kW Capacity



Source: Fueling Development: Energy Technologies for Developing Countries, April, 1992 U.S. Office of Technology Assessment

Barriers for Development of Wind Energy

The utilisation of small wind electric converters within the region is being impeded by several barriers despite the high demand for increased access to electricity and modern energy services in off grid areas and a huge potential for income generation through businesses. However with targeted and concerted efforts, these barriers can be overcome resulting in a wider adoption of small wind electric systems. Key measures to accelerate the use of wind energy that could provide a model for further development include:

i. ***Awareness and technology availability:*** government planners, developers, investors and private sector business do not seem to be aware of the potential for and capability of small wind electric systems.

Relevance, functionality and suitability of small wind electric systems in improved access to electricity in rural or off-grid setting are still not clear to many.

ii. ***Policy directives and incentives:*** in the early 20th century electricity generation and transmission technologies supported the idea that "big is better" a view that is still held by many African governments. Over the last 10 years the technological dynamic is being reversed in favour of distributed power. The challenge now is to develop policies encourage consumers to become producers through use of wind and other renewable sources.

iii. ***Wind energy data:*** one of the most crucial pieces of information needed when evaluating the wind energy potential of any given area or site is reliable wind resource data. Unfortunately and for unclear reasons, wind resources have been systemically underestimated. Maps of the spatial patterns of the average wind speeds and wind power densities, prevailing wind directions, frequency distribution of the wind speed including seasonal variability are imperative.

iv. ***Research co-ordination and dissemination:*** useful outputs from wind research conducted by universities and other research centres are not shared comprehensively with government planners and private sector businesses for the benefit of development.

3.2.4 Small and Mini Hydro

Small-scale hydroelectric systems (under 20 MW) capture the energy in flowing water and convert it to electricity. Hydroelectric energy systems can be either "run-of-the-river" or "pumped storage" and are suitable for stand-alone (isolated) or grid-connected applications. If they are well designed, small hydroelectric systems blend with their surroundings and have minimal negative environmental impacts. As with larger hydroelectric systems, small hydro produces no GHG emissions. The potential for small hydroelectric systems depends on the availability of suitable water flow. Where the resource exists, the development can provide cheap, clean, reliable electricity. Locations are numerous in Kenya, and are often accessible to load centers and to the grid.

It is estimated that there exist at least 3000 MW of hydroelectricity power potential in the category of micro to small projects that are considered uneconomic to exploit. However, it is probable that pre-feasibility studies of these projects may establish economic viability. The government of Kenya is planning to encourage development of such projects by communities and investors alike. To facilitate their development, the government will mobilise resources for undertaking pre-feasibility studies and those commanding high merit economic order ranking feasibility studies be carried out.

Most countries around the world have some existing hydropower capacity, and many countries rely heavily on hydropower for base load electricity generation. Worldwide, hydropower supplies about one-fifth of the world's electricity; in countries or regions where hydro resources are plentiful, hydro supplies as much as 70% of electricity requirements. Many hydro sites have been in use for several years. At many of these sites, modernizing and upgrading turbines and generators will increase their efficiency and/or electrical output. Also, many have not been designed to maximize the full capacity of the site. Additional equipment and/or equipment upgrades may be able to take advantage of this potential without requiring the construction of new dam capacity. Maximizing hydropower generation, which is base load generation, can divert the need for capacity from other, fossil base load electricity sources, and thereby reduce greenhouse gas emissions overall. Also, in countries where existing facilities may be facing relicensing, some capacity may be lost due to new, stricter requirements. Maximizing capacity at other sites may help to offset potential adverse environmental impacts.

3.2.5 Biomass

Biomass and Sustainability

Kenya's pre-dominant energy source is 'traditional' biomass i.e. firewood, charcoal and agricultural waste, possibly contributing up to 80% of Kenya's final energy demand based on the 2002 Ministry of Energy survey information (although there is a lack of accurate data regarding the use of biomass and its environmental impacts). Most Kenyans use firewood or charcoal for cooking and this is having a visible impact on Kenya's dryland savannah and forests especially in fragile ecosystems and near refugee camps,

with negative impacts on water catchment areas, reduced water access and capacity for electricity generation.

Unfortunately, there is no overall policy on biomass and the laws that apply are both incoherent (illegal to make charcoal but legal to sell it) and not enforced, such that the reality is that over 80% of households in urban areas use charcoal and both afforestation and reforestation efforts have not kept pace with biomass use. Although the Minister for Environment and Natural Resources and the Minister for Planning and National Development believe that the ban on charcoal should remain, be tightened and that policy should be focused on shifting towards the use of Liquefied Petroleum Gas (LPG), many families use charcoal and the current ban is not working at all.

There is need for sustainably produced and harvested charcoal to be legalised whilst unsustainable charcoal should be penalised through high taxation. The conference agreed that the government Ministers need to come together to develop coherent policies for charcoal and firewood and manage this valuable renewable resource. Mali and Sudan have tackled these problems, deliberately promoting LPG and making charcoal production sustainable, legal and taxable.

Key recommendations to address the biomass problem include:

- Bringing together Energy, Environment, Planning and Land Ministries to get information from experts, discuss and tackle the biomass issue;
- A single coordinating institute, to implement biomass policy which could be a new body or reinvention of an existing institute;
- Need to formalise and legalising sustainable charcoal and encourage private companies to engage in sustainably produced charcoal, whilst taxing unsustainable and illegal charcoal;
- Addressing landownership of trust land encourage more tree planting on all land with focus on idle land, encouraging a percentage of land to be set aside for trees, and enabling farmers to realise the value of trees or compensation offered;
- Promotion of legal and efficient charcoal kilns and increased use of energy efficient jikos in both urban and rural areas;
- Acquiring better data on biomass use, jobs and livelihood creation and environmental impact; and

- Substituting charcoal for LPG, achieved through supporting commercial promotion of LPG by abolishing VAT and import duty on the gas and appliances, and standardising equipment and importation rules.

There exists a substantial potential for power generation using biogas by the sugar industry for own consumption and export to the grid. Biomass energy utilizes the energy content of agricultural residue, wood waste, animal wastes, or energy crops. These materials are either combusted in boilers to produce steam and/or heat, or gasified. Direct biomass combustion technology is very similar to coal combustion technologies; it is also relatively easy to "co-fire" biomass with coal in existing boilers. Biomass can also be converted into combustible gases, much as natural gas is used to generate electricity or to fuel vehicles. When used to offset fossil fuel use, bioenergy systems can significantly reduce or eliminate GHG emissions. While some GHG emissions may be produced through combustion of biomass for electricity, total emissions/kWh are considerably less than those produced by fossil fuels. Also, if a replacement crop is planted, equivalent to the amount of biomass used for electricity generation, the new crop absorbs the CO2 produced by the combustion process resulting in no *net* emissions. In the world, over two billion people are without electric power, and another billion have less than five hours a day of electricity. Most of these three billion people live in the middle latitudes where biomass grows abundantly, and can potentially be a viable source of fuel.

Advances in biomass combustion technology contribute to its increasing viability.

Constraints in use of Biomass for Power Generation

A large, steady supply of biomass is required for reliable electricity generation. Biomass supply may be climate or season-dependent. Land suitable for biomass development may face competition for other uses and/or there may be opposition to harvesting existing resources such as forests. The cost of procuring feedstock may be prohibitive where biomass must be transported long distances to a combustion site. Since biofuels have a relatively low energy content per ton, bioenergy facilities must be sited close to their fuel source in order to minimize transportation costs. However, co-firing biomass/coal may stabilize the fuel supply for such plants. Typically biomass contains 1-4% non-combustible ash by weight, which

may require special disposal arrangements. Such ash often contains low levels of lead, barium, selenium and arsenic, which must be carefully land filled.

3.2.6 Power Alcohol

Power alcohol was introduced in Kenya as a fuel blend for gasoline in 1983. However, due to management and pricing problems, its use was discontinued in 1993. This fuel blend had a volume composition of 65% super petrol, 10% alcohol, 25% ordinary or regular petrol. The octane number of the blend was 93. The government of Kenya has in its plan to reintroduce power alcohol as a motor fuel in its long-term policy to enhance security of supply and redress the trade imbalance arising from petroleum imports.

3.2.7 Limitations to RETs Wide Adoption and Possible Strategies for Exploitation of the RE resources in Kenya

Though different RE technologies have certain specific limitation to their use, generally the factors that have inhibited the widespread use of the RETs in Kenya have include:

- Lack of public awareness on the technologies existence, use and limitations has remained the most frequently quoted barrier to the commercialization of renewable energy resources in the country. The need for RE education through pilot demonstrations, showcase programs, public education in the through print and electronic media and in public *barazas*, aimed at educating the public, media and policy makers is therefore necessary to surmount the barrier.
- The high up-front cost for these technologies has also made them unaffordable to the potential Kenyan market. The need for financing mechanism (credit scheme) to help the potential market in mitigating the high initial costs is therefore necessary. A Pilot project undertaken by two local companies (technical and financial companies) financed by the world bank between 1997-9, provided a learning curve to the endeavour, and showed that many rural Kenyans would easily adopt the technologies through micro-credit schemes with a higher repayment rate of 96%. Therefore RE dissemination design should include a credit component. Besides there is an inherent need for lobbying with government and financial institutions to recognise the need for credit provision for RETs acquisitions.
- Lack of or low technical skills for the technologies design, installations and maintenance especially in the

rural areas where they required have hampered their uptake as well. Different surveys done by different organisations have document considerable number of the RETS that have stalled due to poor design, installations and maintenance procedures. Besides currently there are no national RETs technical standards to regulate the industry. Even though this is currently under development through the joint effort of RET industry and Kenya Bureau of Standards, the absence has in the past made shoddy dealers to install poor systems leading to the disillusionment of more customers in the neighbourhood of the failed systems.

- The need for technical training to artisans, dealers and technology users is therefore necessary. Lobbying for government to support training curriculum for RETs technology is also needed. Donor funded projects target at RETs dissemination should therefore have training component.
- Institutional and regulatory barriers have continued to impede renewables uptake in the country. Despite the immense potential of these resources the government has had a cold feet in their recognition until 1999 when the country was plunged into serious power shortage. As a result, high taxes levied on the equipments make consumer's pay for them heavily thereby limiting their wider adoptions.
- There is a need to urge the government through ministry of energy to remove institutional and regulatory barriers and adopt effective policies as priority to the implementation of renewable energy. Such policy should for example consider development of alternative energy sources as a 'national energy' resource that can be pooled for collective national utility. This approach fundamentally aims to supplement the national electricity grid with alternative energy technologies, as grid extension to all parts of the country will never be achieved.

3.3 Electrical Power Generation, Transmission And Distribution

3.3.1 Generation

(a) Introduction

Electricity contributes 10% of the country's energy demand. So far, about 15.3% of the 33 million populations have access to commercial electricity. The main sources of

commercial electricity in Kenya are hydro, geothermal and fossil fuel fired generators. The installed capacity of the interconnected system is 1217.6 MW comprising 677.2 hydro, 122 MW geothermal, 0.35 wind, 398 MW thermal, and 20 MW import from Uganda. Seven isolated mini-grids make up a total of 9 MW. The effective capacity of the interconnected system capacity is about 1103 MW, compared to a peak demand of 821 MW in January 2004. The government owned generation utility, KenGen, owns 82% of the installed capacity, while Independent Power Producers (IPPs) contribute 16%. The 2% balance is imported under a contract with the Uganda Electricity Transmission Company. Table 1.1 gives a summary of the installed and effective capacity, while Table 2.2 shows thermal plant data for existing.

Only about 15% of households in Kenya have access to electricity of which 49.7% and 4.8% are urban and rural households respectively. In contrast 32% of households in developing countries have access to electricity.

The total installed capacity of electricity is 1,206.77 MW effective 1,119 MW). Domestic hydropower comprised 677.2 MW, Geothermal 121 MW, Oil-fired thermal 408.0 MW and 0.57 MW wind. Imports from Uganda also contribute 30 MW to the national grid.

After Energy Sector liberalization, four Independent Power Producers (IPPs) are now in operation providing 186 MW. Three of these namely, Iberafrica, Westmont and Tsavo Power Plant are thermal-based injecting 174 MW while or Power 4 is a geothermal plant providing 12 MW.

The Kenya Electricity Generating Company Limited (KenGen), the government owned utility provides 82% while Independent Power Producers (IPPs) generate18% of the effective generating capacity.

Hydro generation sources make up 62.2% of the effective capacity while Geothermal and Thermal contribute 5.4% and 23% respectively. The annual growth in electric power demand is estimated at 6%.

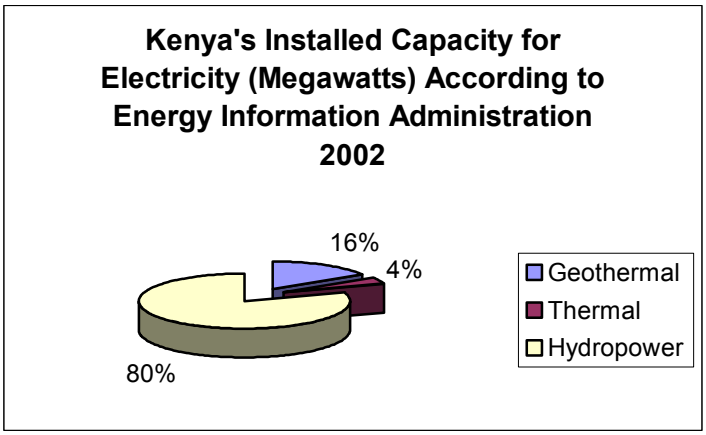
(b) Generation of electricity

Electric power in Kenya is generated through the following sources:

- Hydropower generation
- Thermal (fossil-fuel) electricity generation
- Solar PV
- Wind turbines

- Geothermal

Fig.: 3.4 Kenya's installed capacity for electricity



(c) Electric Power Generation Technologies

Electric power is generated from five main sources namely:

- hydropower
- geothermal
- fossil fuel fired generators
- wind turbines and
- solar pv.

Renewable electricity generating technologies are large and small hydropower, geothermal, wind, power- alcohol, bagasse, solar, municipal waste and biomass.

(d) Committed Projects

Two-generation projects are at the second phase of construction, and are expected to be online after 2006. These are Olkaria III 48MW Geothermal IPP project (12MW is online) and Sondu Miriu 60MW Hydro. KenGen's 2 x 30 MW open cycle Gas Turbines will be converted to a more efficient 120-130MW combined cycle plant.

Import from Uganda will be increased to a firm 50MW in 2007 after they add new hydropower capacity. A regional initiative is also being explored for the interconnection of the Kenya and Tanzanian grids and subsequent importation of power from the Southern African Power Pool (SAPP). The imports from the neighbouring countries will displace some fossil-based thermal generation and delay new investments in thermal plants.

Table 3-3: Shows the installed capacity by type

	Installed MW	Effective MW	Percentage
Hydro			
Domestic	677.2	654.2	55%
Import (UETCL)	20	0	2%
Geothermal	122	122	10%
Wind	0.55	0.46	0%
Thermal	407	348.14	33%
Total	1226.8	1124.8	100%
Peak Power Demand MW		821	

Table 3-4: Thermal Plants Specific Consumption and CO_2 Emission Data

Power Station	**Capacity MW**	**Fuel type**	**Specific Consumption kg/kWh**	**Heat Rate kg/kWh**	**CO_2 Tonne/kWh**
Kipevu Steam	26	HFO	0.35	17,700	0.077
Kipevu I Diesel Plant	74	HFO	0.19	8,800	0.075
Kipevu II Diesel Plant (Tsavo)	75	HFO	0.219	8,800	0.075
Kipevu Gas Turbines	60	IDO/Kerosene	0.32	15,900	0.069
Nairobi Gas Turbine (Fiat)	13	AGO	0.42	20,800	0.072
Iberafrica (Niigata)	44	HFO	0.229	9,000	0.059
Iberafrica (Wartsila)	12	HFO	0.223		
Westmont	43	Kerosene/Gas Condensate	0.27	12,500	0.069
Isolated Diesel Plants	9	HFO/IDO	0.29		

HFO = Heavy Fuel Oil
IDO = Industrial Diesel Oil

(e) Generation by Source Type

Electricity demand grows at about 6.5% annually. Table 1.3 below shows the historical generation since 1994 and the estimated CO2 emission by thermal plants. Table 1.4 shows the percentage contributions from the various types of plant. Hydro generation has continued to decrease over the years while thermal and geothermal generation increase. This has mainly been due to the fact that the last hydro plant addition was in 1991 (Turkwel 106MW). Adverse weather conditions in 1999/00 resulted in a decrease in the hydro contribution. Sondu Miriu hydro station was expected to be online by 1998, but has been delayed due to financing

problems. As a stop-gap measure, two IPP thermal plants were installed in 1997 to meet increasing demand.

Table 3-5: Generation by Type

Year	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03
Hydro	3,048	3,103	3,163	3,354	3,259	3,274	2,435	1,325	2,402	3,120
Imports	264	187	149	144	146	140	155	198	172	222
Geothermal	385	261	290	390	393	366	390	383	429	480
Steam	140	218	224	200	201	141	199	126	94	83
Diesel	17	19	21	29	234	297	707	1,411	1,187	893
Gas Turbine	2	47	171	174	309	394	583	586	227	49
Total (GWh)	3,732	3,864	4,118	4,294	4,515	4,636	4,462	4,075	4,562	4,752
Total CO2 Gg	204	361	506	482	766	819	1,375	1,744	1,160	757

Table 3-6: Annual Energy Generation % Composition by Type

Year	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03
Hydro	82	80	77	78	72	71	55	33	53	66
Imports	7	5	4	3	3	3	3	5	4	5
Geothermal	7	8	9	9	8	8	9	11	11	8
Steam	4	6	5	5	4	3	4	3	2	2
Diesel	0	0	1	1	5	6	16	35	26	19
Gas Turbine	0	1	4	4	7	8	13	14	5	1
Total %	100	100	100	100	100	100	100	100	100	100

(f) Geothermal

Geothermal energy channels the heat and steam stored below the earth's surface to a turbine that then drives a generator to produce electricity. Underground heat sources such as hot water reservoirs can be tapped by drilling through the earth's layers. Some surface manifestations such as hot springs and geysers may also be tapped for electric generation. High-temperature steam sources are of the greatest value for generating electricity; geothermal plants operate over temperature ranges of 122-482°F (50-250°C), a relatively low heat compared to traditional fossil or nuclear plants. As long as resources are sustainably managed, geothermal can serve a base load power generating function with high availability.

Geothermal energy produces minimal amounts of carbon dioxide and only traces of nitrogen oxide and sulfur dioxide emissions. Closed loop systems, the newest generation of geothermal technologies, produce no airborne emissions. As a generator of base load electricity, geothermal competes with fossil fuel power sources. Thus, every kW of electricity generated by a geothermal site

avoids the emissions that would have otherwise been produced by combusting fossil fuels.

For power generation, geothermal is limited to site-specific availability, and locations may not be close to a transmission grid. However, there is tremendous untapped potential for developing geothermal resources in Asia, and new technologies under development will improve the economics of using smaller geothermal sites for power generation, increasing the number of sites with economic potential. Of the five forms of geothermal energy, only two hydrothermal reservoirs and earth energy are currently used for electric power generation. Technological advances must be made before the three other forms geopressured brines, hot dry rock and magma—can be commercially developed.

(g) Fossil Fuels

Petroleum fuels are the most important source of commercial energy in Kenya, and are mainly used in the transport, commercial and industrial sectors. In 2002 the consumption of petroleum fuels in Kenya was 2.3 million TOE, equivalent to per capita consumption of 74 Kilogrammes, a figure that is indeed low even by the standards of developing economies. This low consumption level has been due to economic growth stagnation and over dependence on rain-fed agriculture. Coal is exclusively used in the industrial sector, particularly in the cement industry for process heat. The level of consumption in 2002 was 99,000 TOE.

3.3.2 Transmission and Distribution

(a) Transmission

The power transmission system comprises 877 kilometres of 220kV lines and 2,017 kilometres of 132kV lines. There are also 576 kilometres of 66kV lines, which are used for both power transmission and sub-transmission. The installed capacity of generation substations in service is 1788MVA.

i) Olkaria-Nairobi 220kv Line and Associated Sub-Stations

Construction work for 110km Olkaria-Nairobi 220kV double circuit line, which is part of the Olkaria II Geothermal project being undertaken by KENGEN, is at an advanced stage. The line and substation at Nairobi North will enable power transmission from Olkaria and Olkaria III to Nairobi.

ii) Kiambere-Nairobi 220kV Line

The Kiambere-Nairobi 140km single circuit line whose construction began in February 2001 is complete. This line has improved power transfer from the hydro stations to Nairobi and enhanced security of supply.

iii) Increased Power Imports from Uganda

Kenya Power and Lighting Company (KPLC) has negotiated an agreement with the Uganda Electricity Transmission Company Limited (UETCL) for a firm 50MW import from Uganda. The additional power will be available after completion of the 200MW Bujagali project on the River Nile.

iv) Interconnection to the Southern Africa Power Pool (SAPP)

A feasibility study commissioned by the governments of Tanzania and Kenya for a transmission line between Arusha and Nairobi was completed in November 2002. The study recommended construction of a 200MW 330kV line between Arusha and Nairobi, which would first be operated at 220kV to transfer 100MW. After 2012, Embakasi substation terminal equipment would be upgraded to 330kV and power transfer increased to 200MW.

To facilitate interconnection with SAPP, Tanzania and Zambia have commissioned a feasibility study of a 670km 330 kV transmission line between Zambia and Tanzania, and reinforcement of transmission network within Tanzania.

These two projects will be developed jointly.

(b) Power Distribution

The power distribution network comprises 4,639km of 33kV lines and 10,397km of 11kV lines. The distribution transformer capacity in service is 5,152 MVA broken down into 2,971 substations and 2,181 transformers.

3.3.3 Projected Energy Demand Upto 2020

Woodfuel demand projections indicate that it will rise to about 53.41million tonnes by the year 2020.

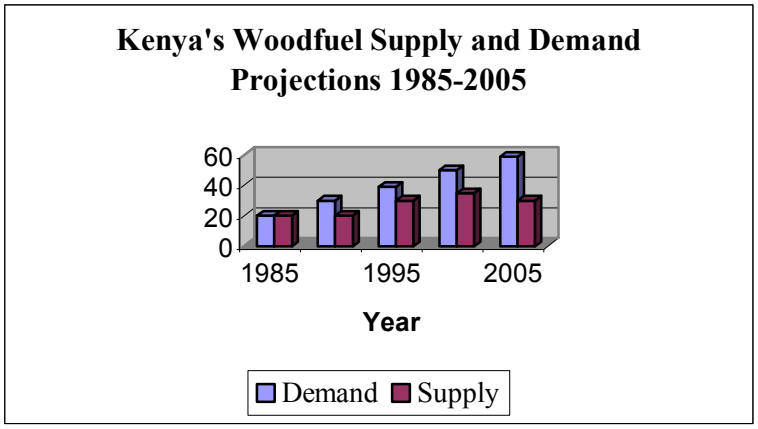


Figure 3.5: Kenya's woodfuel supply and demand projections 1985-2005

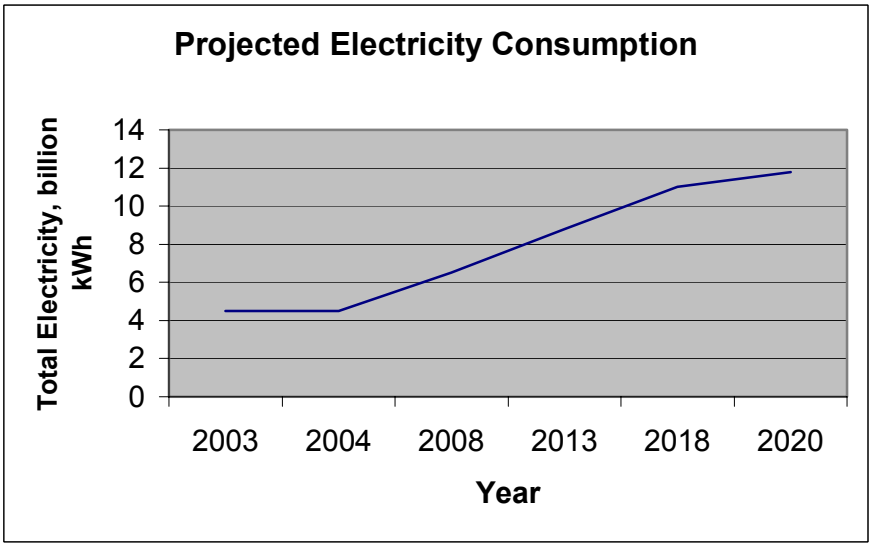


Figure 3.6: Projected electricity consumption in million kWh

Kenya's energy demand is increasing in response to increased economic activities while pursuing the industrialization objective as well as the demographic changes that are taking place. The projected energy demand by 2020 is indicated by table 6 covering the major forms of energy used in the country.

The projections are premised on the assumption that biomass energy demand will continue to grow at about two per cent annually, that electricity demand grows at a uniform annual rate of seven per cent and that demand for petroleum products will remain at constant rate of three per cent per

annum. The foregoing growth factors are derived from the observed long-term trends.

Table 3-7: Projected Energy Demand Upto 2020

ENERGY FORM	CURRENT DEMAND (2003)	PROJECTED DEMAND BY 2020
Biomass	36 million tonnes	53.41 million tonnes
Electricity	1172 MW	2839 MW
Petroleum	2.3 million tonnes	3.5 million tonnes

In addition, the above projections take a business-as-usual scenario that the existing interventions are going to be sustained without introducing other. Well, this may not necessary be the case. However, the wider picture is likely to remain, should there be changes, these may not be drastic.

3.3.4 CO_2 Emission Reduction Potential in the Power Generation Sector

Power generation, especially from thermal sources is associated with emission of greenhouse gases particularly carbon dioxide. By minimizing the quantity of power from this source, further greenhouse gas emissions may be avoided. Switching to lower or no carbon-emitting sources of power would be the only logical step forward in achieving the ultimate objective of UNFCCC as stated under Article 2.

Table 3-8: Amount of CO_2 Emitted from Fossil Fuel Combustion 1994–2001 (Gg CO_2)

PRODUCT	1994	1996	1997	1998	1999	2000	20001
Crude Oil	6407.20	3072.11	5007.77	4748.40	3460.12	7491.9	6004.9
Petroleum Fuels	4	1577.05	739.83	1681.89	1916.68	1330.9	2272.0
Lubricating Oils	16.23	-35.94	-34.41	-45.05	-48.42	102.7	76.4
Refinery Feedstock	308.64	334.36	304.41	306.05	293.34	313.2	264.4
Coke	294.99	346.22	355.17	292.68	284.12	256.6	256.6
Total	**7428.40**	**5293.80**	**6372.77**	**6983.97**	**5905.84**	**9495.2**	**8874.3**

Source: Kenya National Communications to UNFCCC, Meena 2003, Njihia J., H. R. Muturi and P. N. Mbuthi, 1998

In order to appreciate the indicative levels of GHG emissions from the burning of fossil fuels, the table above shows Kenya's historic CO_2 emissions from fossil fuel burning.

3.3.5 Analysis of the Technologies and Comparison of Emissions by Plant Types

a) Hydropower

Flowing water creates energy that can be captured and turned into electricity. This is called hydropower. The common type of hydropower plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. To generate hydropower doesn't necessarily require a large dam. Small hydropower plants just use a small canal to generate electricity.

In the future it is unlikely that we will see any new hydropower stations. Small-scale hydropower, using smaller streams and rivers, can be economic and can provide power to households and industries in the rural areas, or even electricity that can be sold to the National Grid.

b) Geothermal

Geothermal energy channels the heat and steam stored below the earth's surface to a turbine that then drives a generator to produce energy.

Kenya will have an installed capacity of 121 MW of geothermal energy by the end of 2003. Geothermal energy is expected to contribute about 512 MW energy required in the next 20 years as indicated in the National Power Development Plan.

There is an estimated potential of approximately 2000 MW of unexploited geothermal resource that can contribute significantly to GHG reduction if developed because it produces minimal amounts of carbon dioxide and only traces of nitrogen oxide and sulphur dioxide emissions. As a generator of base-load electricity, geothermal competes with fossil fuel power sources. For every kWh of electricity generated by a geothermal site avoids the emissions that would otherwise been produced by combusting fossil fuels.

Therefore more investment needs to be made in geothermal exploration and exploitation.

c) Nuclear Energy

Nuclear power is a reliable, clean and efficient source of energy. It emits no global gases like sources from fossil fuel.

International Atomic Energy Agency has collaboration with the Kenya National Council for Science and Technology. To develop nuclear power plants, the country needs to have appropriate legislation on hazardous waste management, nuclear power know-how and reliable transmission system and a nuclear regulatory body with adequate knowledge and resources.

d) Wind Turbine

Wind energy is a new kind of energy generating technologies and one of the fastest growing sources of energy. Currently wind energy contribution to electric energy in Kenya is about 0.04%. Because wind power is pollution free and cheap power source and also it is an excellent alternative for remote, it is going to be the most common forms of renewable energy for the future. Wind turbines are mounted on a tower to capture wind the most energy. Turbines catch the wind's energy with their propeller-like blades.

The Ministry of Energy recently completed a wind resource map. The resource as been underutilized in the past due to insufficient data and information to assist investors in decision-making. The completion of the wind map will enhance its use from water pumping and grain milling to power generation. Currently, there are two-windmill farm of 0.35MW at Ngong Hills, which injects 1 MW per year into the grid and a single 200kW-turbine hybrid system generating 1.5 GWh per year at Marsabit. Feasibility study of a 50MW wind project is on going. The Marsabit and the Ngong wind feasibility study are not KenGen projects. However, KenGen is planning to convert the 1 MW diesel plant currently serving Lamu Island to hybrid system (wind/diesel) on the main land Mukowe. Feasibility on the same is still to be done.

There is also a lot of potential of wind off shore. Considerations to develop offshore wind turbines have not been discussed. Wind energy produces no GHG emissions. Thus every kWh generated by wind technologies avoids emissions associated with a similar number of fossil –fuel generated kWh.

e) Fossil Fuel (thermal and gas turbine)

Table 3-9: Emission per plant type

Plant type	Specific	CO2 g/kWh	Sulphur g/kWh	Methane g/kWh
Fossil Fuel	Oil	850	11	0
	Gas	550	0.005	0
Geothermal	Steam	96	6	0

3.3.6 Mitigation Options In The Electric Power Generation Sector

a) Brief background

Kenya Electricity Generating Company (KenGen) is the leading electric power producer in Kenya providing about 80% of the national electric energy requirement. The company's interconnected generation facilities have an installed capacity of 1,065.4 mega-watts, comprising 674.5 MW hydro, 105 MW geothermal, 281.5 MW thermal and 0.4 MW wind.

The Company proposes to implement an Integrated Environmental Management System (EMS) in the electric power generating stations of KenGen with thermal and geothermal power stations as pilot sites of the system implementation.

b) Current Environmental Management System and Activities

There are a number of significant adverse environmental impacts associated with electric power generation. These include amongst others air pollution, water pollution, waste disposal impacts and ecological disturbance.

To mitigate the above environmental concerns of its generation facilities, KenGen has instituted various environmental management programmes in its power stations for the purpose of protecting the wider environment.

In the Geothermal power development, the following monitoring activities are in place: ambient air quality (H_2S), environmental noise, precipitation chemistry, meteorological conditions, solid waste disposal and power plant hygiene, waste water quality (Temperature, pH, Conductivity, Arsenic, Mercury, Cadmium, Lead, Copper, Zinc, Barium, Lithium, Boron and Fluoride), civil works, geothermal drilling operations, geothermal well testing discharge and flora and fauna.

Environmental monitoring activities in the Thermal and Diesel Generating Power plants include the following: emissions to air (CO_2, NO_x, SO_2, and particulate matter), releases to water (pH, Temperature, Oil and grease), sewage effluent discharge to land (Total Suspended Solids and 5-Day Biochemical Oxygen Demand), ambient air, water and noise quality, and rehabilitation of the site through landscaping, planting of indigenous plant species, general site cleanliness and "Housekeeping".

In the Hydro Electric Power Plants (HEPP) the following activities are undertaken: soil conservation, social afforestation programmes, oil spill control and management, general site '*Housekeeping*', water treatment and waste management, control of aquatic weeds infestation.

Most of the above monitoring activities are performed manually with hand-held instruments since no automated Environmental Monitoring Systems has been installed in the power plants for real-time data recording, analysis and reporting. The manual processes of environmental monitoring have inherent inadequacies, which the proposed EMS attempts to address in order to achieve effective and efficient environmental management.

To improve on the effectiveness and efficiency of the above instituted management programmes, the Company intends to implement an Integrated Environmental Monitoring and Management System in its thermal and geothermal generation plants to monitor and control pollution of key environmental elements thus air, water and land.

c) Pollution Monitoring and Control

Implementation of an Environmental Management System (EMS)

d) Proposed Integrated Environmental Management System for KenGen

In view of the foregoing identified management weaknesses and need for compliance with environmental legal requirements and relevant international environmental standards and guidelines, KenGen has opted to develop and implement an Integrated Environmental Monitoring and Management System (EMS).

i) Objectives and Aims of the proposed EMS

Objectives

The primary objectives of the proposed EMS:

- Monitoring and control the environmental impacts of the significant environmental aspects of power generation;
- To protect KenGen from future liabilities of the environmental risks by providing scientifically proven data on environmental pollutants;
- To assist in sustaining the various power plants and project operations through environmentally sound and socially acceptable practices.

Aims

- Ensuring global public acceptance of KenGen's activities, products and services
- Ensuring KenGen's compliance with the existing Kenyan Environmental Legislation and some relevant International Environmental Guidelines and Standards of bilateral financial institutions that include The World Bank Group, Japanese Bank of Investment and Corporation (JBIC) and other Agencies funding power development projects executed by KenGen.
- Certification of all KenGen's operations and management by the Organisation of International Standards, ISO, on attaining the ISO 14000 standard on Environmental Management Systems (EMS).

ii) Significance and Benefits of the proposed EMS

Benefits

- The installation of the EMS shall result in achieving the following:
- Improvement of company's image in the global field of environmental management
- Social responsibility and acceptance
- Saving on expenses and time
- Introduction of more extensive and efficient environmental pollution prevention into the company operations, which will be prepared for changes in technology and legislation
- Reduction of GHG emissions
- Certification of company management and operations with International Standards such as ISO 14000 series on EMS

iii) Provisional Cost Estimates

The summarized Cost Estimates have been obtained using average data retrieved from various Environmental Equipment Suppliers and Consultancy Companies quotations at the time of compilation of this proposal, some of which are detailed in Appendix B and C of Doc. IEMMS001.

The Estimated Costs, however, do not include the cost of the Reorganization of the Company with respect to the Proposed Environmental Management Organizational Requirements detailed Doc. IEMMS001.

Table 3-10: Summary of Provisional Estimated Costs for EMS implementation in Olkaria and Kipevu Power Plants.

EMS Implementation	Item Description	Qty
Olkaria I Geothermal Emission	Instrumentation (Gas Sampling Probes, Gas Analyzer, Data Logger)	1
Olkaria I & II Geothermal Emission	Instrumentation (Gas Sampling Probes, Gas Analyzer, Data Logger, Data Transmission)	4
	Study and definition of Emission Monitoring Network Model	1
Olkaria Geothermal Waste Management	Study of Waste Management and Procedures	1
Kipevu Gas Turbine Emission	Instrumentation (Gas Sampling Probes, Gas Analyzer, Data Logger, Data Transmission)	2
Kipevu Gas Turbine and Diesel Power Plant Operations	Definition of Plant Operational Procedures for Environmental Management	1
Kipevu Gas Turbine, Diesel and Steam Power Plant Waste Management	Study of Waste Management and Procedures	1
EMS Platform for Olkaria & Kipevu Power Plants	Hardware and Software	1
Total Estimated Cost		

iv) Capacity Building and Training

Capacity building needs for the effective implementation of climate change mitigation actions is very important. This is an area that needs be given high priority. Capacity building will entail development of both human and institutional and infrastructural capacities required to facilitate implementation of climate change mitigation actions. It will involve training to improve managerial as well as technical expertise to help institutions comply with environmental regulations. With improved management, environmental benefits will minimize losses and wastes. To improve human and plant performance, provision of tools and equipment is necessary.

To achieve the objectives for implementation of the said actions, financial and technical support is needed. The UNDP/ World Bank Energy Sector Management Program provides such a support to such programs.

v) Conclusion

The current environmental management system in KenGen has apparent weaknesses. These include lack of an elaborate policy, objectives and targets, institutional framework, plans, procedures, processes and practices on environmental management of impacts of emissions, effluents and waste generated from its power generating plants.

Despite the above shortcomings, KenGen's overall management of environmental risks resulting from its operations is well managed. However, KenGen recognizes the need to improve and strengthen the current EMS by installing an Integrated EMS to address the above inadequacies and to be compliant with the obligations of the Kenyan Environmental Legislation of 1999 and international criteria and standards.

The implementation of the proposed Integrated EMS shall assist KenGen achieve the following benefits:

1. Accurate monitoring and control of emissions to the atmosphere, effluent discharges to international water bodies and aquatic environments and waste products
2. Prepare an elaborate strategy and targets for minimizing global emissions, effluent discharge and wastes
3. Adopt cost effective methods of resource utilization during power generation operations
4. Ensuring that the power development projects are sustainable and environmental friendly

vi) Recommendation

Considering that environmental issues are of global concern, KenGen, is putting this proposal for consideration for financial support from Climate Change Mitigation Project Support Fund and Global Carbon Initiative of the World, to implement this noble initiative of preventing global environmental pollution.

The cost of development and full implementation of the proposed EMS in the thermal and geothermal plants is US$1m.

vii) Feasibility Study of Rehabilitation of Small Hydropower stations

Small hydropower projects are defined to be installations with generation capacity ranging from 1-20 MW. The fundamental thesis for the small hydropower as a concept is that the impacts of their implementation are minimal since most of them are either "run-of-river" or "pumped storage". Apart from increasing power generation capability, they will also substitute thermal plants in the least cost plan helping to reduce emissions of GHG to the atmosphere.

KenGen has about six small hydro plants, with an installed capacity of 6.28 MW and aims to rehabilitate five of them. All of these stations were built between 1925 and 1958 and have therefore outlived their useful economic life. The proposed rehabilitation works will include automation and capacity increments that will enhance kWh energy per year.
In order that the rehabilitation works are carried out in a systematic manner, it is proposed to do a comprehensive feasibility study that will look at the possible improvements of all these plants, do a cost-benefit analysis and estimate their power output and determine their comparative ranking.

The re-development of small hydro-power projects will not only contribute to reduction of GHG emissions but will cause minimal natural and social impacts and will benefit women by reducing their chores and providing electricity for schools, rural health centers and industries. In this way it will create new jobs in the rural areas.

The feasibility study is estimated to cost US $ 2 million.

3.3.7 Measures for Greenhouse Gas Emission Reduction Or Avoidance

a) Introduction

The table below shows some suggested measures for reducing and/or avoiding greenhouse gas emissions. As discernable from the inventory of energy technologies, there is need for national capacity to build in order to be able to determine basic operational technology characteristics.

Table 3-11: Measures To Reduce GHG Emissions

	Measures	GHG Reduction Potential
Power supply	▪ Switch to low carbon emitting technologies (minimize or avoid fossil-fuel based generation) ▪ Exploit more of the geothermal resource ▪ Exploit renewable sources of electricity ▪ Enhance biomass energy supplies to achieve sustainability	Not quantified
Electricity transmission & distribution	Increase transmission and distribution efficiency and hence minimize the losses.	A reduction of current transmission losses from 20-15% would translate into about 60MW savings, meaning the emissions associated with such production capacity are avoided
Energy Consumption	Increase end-use efficiency through wider adoption of efficient devices e.g. improved stoves, energy-saving bulbs and other appropriate energy conservation practices	The GHG reduction potential (unquantified) is significant

b) Greenhouse Gas Emission Reduction Potential in the Transmission and Distribution Systems

The overall system losses currently stand at about 20%. By the world standards, this level is too high. There is an on-going initiative on transmission loss reduction, which targets to reduce these losses to less than 15% in the next three years.

Transmission losses mean that out of the total installed capacity, the effective capacity or available capacity is greatly reduced by the proportionate percentage losses. If

the losses are reduced, it means more power will be available and this has the cascading effect of reducing the overall generation expansion requirements and hence effectively reducing the GHG emission, which could have otherwise been released.

c) Greenhouse Gas Emission Reduction Potential in the Consumption Sectors

To reduce greenhouse gas emission potential from the consumption sectors, two broad strategic approaches are available, namely end-use efficiency improvement and switching to lower GHG emitting energy sources. At the end-use level, a variety of higher efficiency devices, including improved charcoal and wood stoves and energy-saving bulbs, such as compact fluorescent lamps, to name but a few.

Switching to other sources of energy such as solar, wind, micro hydro and geothermal for lighting and other uses in place of fossil fueled lighting and cooking. This would enhance the benefits of emissions avoidance and/or reduction that are associated with fossil fuels. If for instance, renewable sources of energy would account for at least 5% of the overall energy supply, this would translate into significant reduction or avoidance of GHG emission.

At the consumption level, particularly where fossil fuels are used, significant quantities of GHG are emitted as shown below.

Table 3-12: Historic GHG Emission by Consumer Category (Gg CO_2) 1996 – 1999

Consumer Category	1996	1997	1998	1999
Agriculture	217.1	261.3	286.3	242.1
Road Transport	2498.8	3008.1	3296.4	2787.5
Tourism	21.1	25.9	27.9	23.6
Marine	148.2	178.4	195.6	165.4
Civil Aviation	952.9	1147.1	1257.1	1063.0
Industry	900.00	1083.4	1187.3	1004.0
Government	47.6	57.4	62.8	53.2
Power Generation	497.6	599.1	656.5	555.1
Balancing Item	-10.5	-12.1	-14.1	-11.9
Total	**5293.8**	**6372.8**	**6984.0**	**5905.8**

Table 3-13:Approximate Carbon Emissions from Sample Biomass and Conventional Technologies

Fuel and Technology	Generation Efficiency	Grams of CO2 per kWh
Diesel Generator	20%	1320
Coal Steam Cycle	33%	1000
Natural Gas Combined Cycle	45%	410
Biogas digester and diesel generator (with 15% diesel pilot fuel)	18%	220
Biomass steam cycle (biomass energy ratio[a] = 12)	22%	100
Biomass gasifier and gas turbine (biomass energy ratio[a]=12)	35%	60
[a] *The energy of the biomass produced divided by the energy of the fossil fuel consumed to produce the biomass*		

From Table 5, transport sector is the major emitter of GHGs owing to the extensive use of fossil fuels. Here, in the transport sector, the key measures for minimizing CO_2 emission are in the area of fuel efficiency improvement and practices, use of unleaded gasoline and retrofit of catalytic converters.

3.3.8 Power Development Plan

KPLC updates out Least Cost Power Development Planning on behalf of Government. Feasibility studies for candidate projects provide information required for analysis. Environmental impact assessment is mandatory before project implementation. Feasibility studies done indicate that Kenya's hydro potential exceeds 1400 MW, capable of supplying an average estimated generation of 6000 GWh/yr. The geothermal potential is estimated at over 2000MW.

a) 2003/04 Least Cost Development Plan

Since most of the economic hydro projects have been developed, the next large block resource to be exploited will be geothermal. In the recent past, hydro projects have faced problems related to displacement of locals and high costs of compensation making them less attractive despite being less destructive to the environment. Table 2.1 below shows the forecast used in the preparation of the 2003 development plan summarized in Table 2.2.

Table 3-14: The Load Forecast

Fiscal Year	Net Energy (GW.h)	Peak Load (MW)
2003/04	5,026	829
2004/05	5,286	873
2005/06	5,602	926
2006/07	5,944	983
2007/08	6,302	1,043
2008/09	6,737	1,116
2009/10	7,212	1,195
2010/11	7,717	1,280
2011/12	8,255	1,370
2012/13	8,840	1,467
2013/14	9,436	1,567
2014/15	10,085	1,676
2015/16	10,775	1,791
2016/17	11,509	1,914
2017/18	12,307	2,048
2018/19	13,123	2,184
2019/20	14,020	2,334

Table 3-15: Least Cost Development Plan: 2004-2019

Year	Configuration	Station	Type	Added Capacity, MW	Effective Capacity	Peak Forecast MW
2003/04	-1 x 10	Nairobi South GT	Gas Turbine	-10		
	2 x 30.7	Oikaria II		61.4	1,102	829
2004/05	-1 x 26	Kipevu Steam	Steam	-26		
	-1 x 43	Westmont	Gas Turbine	-43		
	-1 x 30	Kipevu GT1	Gas Turbine	-30		
	-1 x 30	Kipevu GT2	Gas Turbine	-30		
	2 x 30	Kipevu Combined Cycle	CC	60		
	1 x 70	Kipevu Combined Cycle	CC	70	1,103	873
2005/06	2 x 18	OrPower 4	Geothermal	36	1,139	926
2006/07	2 x 30	Sondu-Miriu	H	60		
	1 x 132kV	Sondu-Kisumu	Line			
	2 x 20	MSD - Nairobi		40	1,239	983
2007/08	1 x 50	Import from Uganda	Imp	50	1,289	1,043
2008/09	3 x 20	MSD - Nairobi	Medium Speed Diesel	60	1,349	1,116
2009/10	-3 x 14.4	Olkaria I	Geothermal	-43.2		
	2 x 10.3	SAHP	Hydro	20.6		
	1 x 50	Non-firm Tanzania	Imp	50		
	1 x 67.2	GEOT	Geothermal	67.2		
	3 x 20	MSD - Nairobi	Medium Speed Diesel	60	1,504	1,195
2010/11	3 x 20	MSD - Mombasa	Medium Speed Diesel	60		
	1 x 330kV	Rabai-Nairobi	Line			
	1 x 132kV	Kipevu-Rabai	Line		1,564	1,280
2011/12	1 x 100	SAPP Import	Imp	100	1,664	1,370
2012/13	3 x 20	MSD - Mombasa	Medium Speed Diesel	60	1,724	1,467
2014	1 x 67.2	GEOT	Geothermal	67.2		
	1 x 330kV	Olkaria - Nairobi	Line			
	2 x 20	MSD - Mombasa	Medium Speed Diesel	40	1,831	1,567
2014/15	6 x 20	MSD - Mombasa	Medium Speed Diesel	120		
	1 x 330kV	Rabai-Nairobi	Line			
	1 x 132kV	Kipevu-Rabai	Line		1,951	1,676
2015/16	1 x 67.2	GEOT	Geothermal	67.2		
	2 x 20	MSD - Mombasa	Medium Speed Diesel	40	2,058	1,791
2016/17	1 x 67.2	GEOT	Geothermal	67.2		
	3 x 20	MSD - Mombasa	Medium Speed Diesel	60	2,186	1,914
2017/18	2 x 70	Low Grand Falls	Hydro	140		
	2 x 220kV	L.G.Falls - Kiambere	Line		2,326	2,048
2018/19	1 x 67.2	GEOT	Geothermal	67.2		
	4 x 20	MSD - Mombasa	Medium Speed Diesel	80	2,473	2,184

b) Regional Initiatives

A regional power development plan is being prepared for Kenya Uganda and Tanzania. A study on interconnection of Kenya and Tanzania was done recently and the two countries are pursuing implementation. Once implemented, Kenya can be able to import some power from Tanzania in the medium term, and later on from the Southern African Power Pool (SAPP) after a Tanzania-Zambia interconnector is done.

Ten countries in the Nile Basin are consulting on ways of power grids interconnection and optimal exploitation of the River Nile resources under the Nile Basin Initiative (NBI). Bilateral discussions on Ethiopia-Kenya interconnection are expected to start in the near future.

3.3.9 Technology Needs

a) Loss Reduction

The total power system losses rose from 15.2% in the year 1993/94 to 21.5% in the year 1999/2000. Measures to reverse the trend have been instituted. KPLC targets to reduce the losses from 20% in 2003 to 15% in 2006.

The main causes of transmission losses are:

- power transfer over long distances at sub-optimal voltage level and conductor sizes which may be so due to saving of cost at the time of construction.
- Losses due to transformer and sub-station equipment - step up for transmission or step-down to distribution feeders

b) Measures being instituted to curb losses include:

i. Implementation of major system reinforcement schemes
ii. Optimisation of relevant information systems
iii. Installation of grid meters to facilitate segregation of transmission and distribution losses.
iv. Reduction in commercial (non-technical) losses will be achieved by:-
    - Enhancing meter installation inspection country wide to identify and replace faulty and tampered meters.
    - Inspecting the network and customer connections to identify, investigate and eventually eliminate illegal consumption of electricity occurring through complete or partial meter by-pass.

- Improving staff attitude and effectiveness of system loss reduction teams
- Enhanced maintenance and repair of the existing system; and
- Loss Reduction Teams established to coordinate initiatives

Tables 3-16 and 3-17 below show the level of system losses. Savings can be made through reduction of technical losses by system upgrade and reinforcement, and stringent measures instituted at consumer level.

In order to separate transmission losses from distribution and commercial losses metering points have to be introduced to enable separation. Further separation is required in order to isolate commercial losses from distribution are being pursued. Of the 20% system losses in 2003, technical transmission and distribution losses were 3.5% and 12.5% respectively. Non-technical losses are estimated at 4%.

Table 3-16: Analysis of System Losses

	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03
KPLC Generation GWh	3,724	3,858	4,111	4,285	4,506	4,626	4,451	4,071	4,554	4,740
RE Generation	8	7	8	11	10	11	10	10	10	10
Total Generation GWh	3,732	3,866	4,119	4,296	4,516	4,637	4,461	4,081	4,564	4,750
Auxiliary Consumption1 GWh	38	45	52	44	41	35	0	0	0	0
Sales (Interconnected) GWh	2,996	3,089	3,269	3,406	3,498	3,564	3,366	3,091	3,498	3,654
Sales (RE) GWh	138	134	138	150	146	153	138	121	130	147
Total Sales GWh	3,134	3,223	3,407	3,556	3,644	3,717	3,504	3,212	3,628	3,801
Total System Losses GWh	560	597.6	660	696	831	885	957	869	936	949
System Losses %	15.2%	15.6%	16.2%	16.4%	18.6%	19.2%	21.5%	21.3%	20.5%	20.0%

Notes:
From 1996/97 auxiliary units equivalent to zero due to transfer of ownership of power stations to KenGen.
RE means Rural Electrification Programme, operated and managed by KPLC on behalf of Government.
The World Bank (IDA) has provided some credit for the Distribution Reinforcement and Upgrade project, which is expected reduce losses. Funding of the transmission reinforcement has not been obtained. The table below gives a description of recommended projects that would lead to a reduction in transmission losses. The estimated total cost for these projects is US$48.1 million.

Table 3-17: Transmission Projects

	PROJECT TITLE	REGION	PROJECT OBJECTIVES	DESCRIPTION OF WORK	Cost Million (US$)
1	66kV capacitors at Embakasi Substation	NAIROBI	To provide voltage support and improve performance of 220kV transmission network.	Install at least 80MVAR of capacitors at Embakasi 220/66kV substation.	2.75
2	Rabai Shunt Reactors	COAST	Improve voltage regulation at Rabai Substation	Install 2x12.5 MVar Reactors	0.34
3	Naivasha & Lanet Substation Rehabilitation	WEST KENYA	To reduce interruptions to the distribution system in Central Rift and Olkaria generation due to faults on the 132kV Nairobi - Lessos lines.	Install 6 x 132kV circuit breakers.	3.65
4	Kamburu - Meru 132kV line	MT. KENYA	To improve voltage regulation in Meru area and create capacity for future growth	Construct 130km of 132kV line from Kamburu to Meru including terminal equipment at both ends.	14.50
5	Kisii 132/33kV Substation	WEST KENYA	Recommended in loss reduction studies due to low voltages and losses in Kisii and beyond and supply reliability to the tea Factories	Construct 60km of 132kV line from Chemosit 132/33kV substation and establish 1 x 23MVA 132/33kV substation at Kisii with 2No. out going feeders.	7.83
6	Diani 132kV line &Substation	COAST	Reinforce 33kV network in this tourist destination and cater for load growth.	Construct 45km of 132kV line from Rabai S/S to Diani and establish 1 x 45 MVA 132/33kV with 2 feeders.	8.57
7	Malindi 132kV line & substation	COAST	Reinforce 33kV network in the area which is a tourist destination and cater for load growth.	Construct 60km of 132kV line from Kilifi 132/33kV substation and establish 1 x 23MVA 132/33kV substation at Malindi	10.46
	TOTAL				**48.1**

c) Power Development Planning and Power System Simulation

i) Generation Planning

Power development planning, which is currently carried out by KPLC on behalf of Government, determines the direction of investment in the power sector. A software called GENSIM acquired from Acres International Limited consultants is used for generation simulation, and Acres Reservoir Simulation package used for simulating the hydro system performance by KenGen. KPLC acquired Wien Automatic Simulation Package (WASP) from The International Atomic Energy Agency as assistance in capacity building. One engineer from KPLC and one from KenGen received training on the use of the package for power system planning. There is need for capacity building in form of training more engineers and economists who do planning work. A new load forecasting software is required, besides technology transfer in training to improve on planning function. System planning identifies the technology to be applied to meet the growing system demand. The choice of technology has environmental impacts which can be related with climate change.

Optimal plans help to avoid unnecessary investment and therefore economic burden on the country. Accurate forecasting techniques, selection of generation technology, and optimal simulation techniques contribute to mitigating measures for climate change.

ii) Power System Simulation

Analysis of the Kenya's interconnected system is performed using the Power System Simulation package for engineers, PSS/E. KPLC acquired the software from Power Technologies Inc. of USA. It has been paying maintenance and license fees of close to US$20,000 per annum. The software enables carrying out load flow and system stability studies. Weak parts of the system can be identified and system performance optimized. Only two softwares are available, one for the transmission and one for the distribution system. KPLC can be given assistance by additional software as well as aid for annual fees and manpower development for better management of the system.

iii) Plant Dispatch

The power system is operated under instructions from the National Control Centre. Training on optimal plant dispatch and general system operation can boost system efficiency. This can be further enhanced by acquiring optimal plant dispatch software.

iv) Wood Poles for the Distribution Network

Most of the power distribution network is constructed using wood poles. As the system expands, more poles will be required, and thus exert more pressure on the endangered forest cover in the country. Until recently, most of the demand for wood poles was met by local supplies. There are likely to be more imports from central and southern Africa in the future.

An alternative to wood poles would be steel and concrete poles. Small locally produced steel poles are used in the municipal street lighting system. A few concrete poles found in the city were installed over twenty years ago. In order to save forests and therefore mitigate against climate change, Kenya needs technology to manufacture steel and concrete poles at competitive prices.

3.4 Petroleum and Gas

3.4.1 Introduction

Petroleum products play a major role in the advancement of socio-economic development of any country, Kenya included. In the transport sector they are used in the provision of motive energy. In the commercial and industrial sector they provide process energy for production of goods and services, including power generation. At the household and institutional levels they are used for cooking, lighting and heating activities.

However, despite the key role petroleum products play in moving the wheels of the economy, they also greatly contribute to generation of the Greenhouse Gases (GHG) that are a source of Global Warming hence Climate Change. It is therefore imperative that the problem of GHG emissions is addressed by all the players in this sector with a view to employing ESTs, which while contributing to the global objective of reducing emissions of GHGs into the atmosphere would not frustrate the country's efforts to meet its objectives of sustainable development.

In this section attempts have been made to address the status of petroleum sub sector in Kenya today and it's possible impact on environment with regard to GHG emissions. It provides highlights on current petroleum fuels consumption and demand projections, refinery contribution, comparison of Kenya and other economies, oil exploration today, overview of distribution network, losses

by pipeline transportation and the prospects of reduction of GHG emission in the sector.

3.4.2 Petroleum Sub-Sector Institutions

Both the public and private sectors own the oil supply and distribution network in Kenya today though marketing of petroleum fuels, lubricants, bitumen and other non-fuel petroleum products is mainly controlled by private companies, the key players being;

Table 3-18: Key Players in the Petroleum Sector

Company	Market Share (%)
KPRL	-
KPC	-
Kenya Shell/ BP	20
Caltex	14
Total	15
Kenol/ Kobil	12
NOCK	9
Mobil	8
Independents	22

3.4.3 Consumption and Projected Demand

During the period 1998/99 - 2002/03 the domestic petroleum demand averaged 2.4 Million Metric Tonnes per annum (representing 25.7% of total annual import bill), with the main consumers being; road, rail, marine and aviation. (**1998:2,293.2 1999:2,401.8 2000:2544.4 2001:2466.5** and **2002: 2383.3 '000 Tonnes** respectively).

During the period 1998- 2002 total imports of petroleum products maintained a downward trend except for the lub oils and grease as shown below; this period also represents a time when the crude oil volumes handled by the refinery record a marked drop due to market liberalization.

Table 3-19: Imports and Exports of Petroleum Products (1998 – 2002)

	Quantity (000) tones				
IMPORTS	**1998**	**1999**	**2000**	**2001**	**2002**
Crude Oil	2,157.7	2139.3	2452.3	1965.6	1493.4
Petroleum Fuels	1387.8	1250.9	874.9	1208.3	1023.5
Lub Oils	38.2	41.5	40.0	29.7	33.6
Lub greases	2.2	0.8	0.9	0.7	11.7
Total	3,585.8	3432.5	3368.1	3204.3	2562.2
	Quantity (000) tones				
EXPORTS	**1998**	**1999**	**2000**	**2001**	**2002**
Petroleum Fuels	640.6	627.3	441.9	469.1	190.6
Lub Oils	8.1	3.9	4.8	3.5	4.5
Lub greases	0.2	0.2	0.1	0.1	0.1
Total	648.9	631.4	446.8	472.7	195.3
NET BALANCE	2936.9	2801.1	2921.3	2731.6	2366.9

The overall domestic demand for petroleum fuels is projected to rise to **2.93 Million Metric Tonnes** by the period **2009/2010.** (Assuming GDP growth of 5% and population growth of 3% during this period). The KPRL contribution to this demand has show a steady nosedive as pointed out earlier and this is to remain so as long as the refurbishment of the plant is not done. (The Diesel and Gasoline receipts from KPRL are high sulphur and leaded products respectively).

Table 3-20: Refinery contribution to the petroleum fuels demand (domestic and export) for the period 1999-2003

YEAR	REFINERY % CONTRIBUTION (FUELS)
1999	39.4
2000	41.5
2001	33.0
2002	30.4
2003	23.7

The globalised demand (export and domestic) projections to be handled through the country is as follows; **2005 (6647128 m³), 2010(7646975 m³), 2015(8685755 m³).** These will mainly be received as low sulphur and unleaded products beside the other products that specifications have remained unchanged world over i.e. illuminating kerosene and Jet-A 1 fuels.

Over 70% of commercial energy consumption in Kenya today is from oil with electricity and coal accounting for the balance.

The country's commercial energy consumption however is still quite low compared with the other trade partners and the High Income Economies (HIE) of the world. (See table below). This is due to Kenya's weak and sluggish economy.

Table 3:21 Commercial Energy Consumption

	PER CAPITA COMMERCIAL ENERGY CONSUMPTION (koe/capita)	
COUNTRY	**1971**	**1994**
Kenya	116	110
Egypt	213	600
South Africa	1993	2146
Malaysia	435	1699
Singapore	1551	8103
HIE	4407	5066

From the table above, it is apparent that Kenya's GHG contribution is negligible in comparison with the First World economies (1994 GHG emissions from developed countries in gigagrams: US (6727997), UK (679850), Japan (1330555), Germany (1019745), Russia (1962441).

(a) Petroleum fuels

The main problem affecting this sector is the high cost of petroleum products due to inefficiency of the Kenya Petroleum Refineries Limited (KPRL), which is passed on to consumers. To address this problem, the following will be implemented: -

- An independent study to establish the economic viability of the continued operation of KPRL relative to imports of petroleum products will be completed and its findings will help the Government to make a decision on the future of KPRL;
- A study to standardize LPG cylinders, gas regulators and valves to allow flexibility of usage is at an advanced stage of completion. The study's recommendations on an appropriate legal and regulatory framework to enforce standardization of cylinder valves and regulators will be incorporated in the Petroleum bill expected to be tabled before Parliament by March 2004;
- Construction of LPG import handling and storage facilities at Mombasa and of bulk storage facilities in Nairobi;
- Acceleration of the pace of prospecting for fossil fuels;

- Enhancement of the share of new and renewable energy in Kenya's energy supply matrix; and
- The Government will publish a Petroleum bill whose aim will be to regulate the Sector and protect the consumer from adulteration, dumping and misuse of monopoly power.

(b) Pipeline transport

Pipeline transport is crucial to the economy in facilitating the speedy and safe delivery of petroleum supplies to the hinterland. In this regard, the petroleum pipeline will be extended to Kampala during the Plan period.

Making energy available at affordable costs means increase in use of energy and hence increase in emission of greenhouse gases. It is therefore imperative that measures are immediately put in place to reduce the emission of greenhouse gases as a result of energy use without compromising Kenya's development agenda. Increase of emission of greenhouse gases is directly linked to climate change.

3.4.4 Options to Limit or Reduce Greenhouse Gas Emissions and Enhance Sinks

At the global level, advances are taking place in a wide range of technologies at different stages of development i.e., the market introduction of wind turbines, the elimination of industrial by-product gases such as Nitrous Oxides (NO_X), the advancement of fuel cell technology and the demonstration of underground carbon dioxide storage. Technological options for emissions reduction include improvement efficiency of end use devices and energy conversion technologies, shift to low-carbon and renewable biomass fuels, zero-emissions technologies, improved energy management, reduction of industrial by-product and process gas emissions, and carbon removal and storage. Some of the key areas of consideration are:

- Technologies and practices for end-use energy efficiency in buildings, transport and industry
- Energy supply and conversion
- Low carbon energy supply systems
- Minimization of emissions of fluorinated gases through process changes, improved recovery, recycling and containment, or avoidance through alternative compounds and technologies.

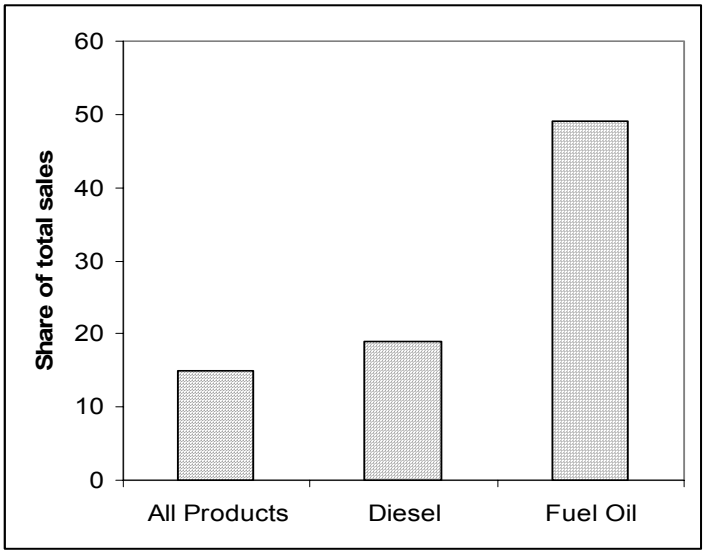
3.4.5 Developments in Petroleum Products

Development of the petroleum sector is mainly geared towards improvement of the competitiveness within the sector. Liberalization of this sector has resulted in competition, which is desirable as opposed to direct Government controls in price and supply for commercial activities. Modalities of extending the oil pipeline from Eldoret to Kampala are underway in line with the policy of transporting petroleum products by pipeline or rail as opposed to road transport.

(a) Petroleum Market Composition

Unlike electricity, the retail market for gasoline and jet fuel dominates the petroleum products market. In addition, substantial amounts of diesel and fuel oil are used for electricity generation by KenGen and Independent Power Producers (IPPs) and thus not for industrial production. Even in the diesel market that is traditionally dominated by commercial and industrial use, agriculture uses have a substantial share.

Share of Commercial and Industrial Sectors in Petroleum Products Consumption, Year 2000 Fig.3-7



(i) Structure of the Petroleum Products Market

The structure of petroleum market can be summarized as follows. The major oil companies or majors, i.e., Shell, Total, Caltex, Mobile and Kenol/Kobil, have almost total control over the primary supply sources (all refinery output and the largest proportion of international

imports). The port situation at Mombassa does allow independent oil companies to import products as well. While the absolute level of these imports is low, these companies often escape the requirement to buy from the refinery and thereby have a lower cost product supply.

The resale market in Kenya is considered quite large with its size estimated at 20% or more. The majority of supply in this market comes from the majors selling to resellers. The reason for such fragmentation of the supply change relates to majors not wanting to fully integrate their supply network and logistical limitations that cause reliance on third-party marketers in rural areas.

3.4.6 Oil Exploration in Kenya

This has picked up in earnest in late '90s, especially with the introduction by the government of the more favorable system of Production Sharing Contracts (PSCs). The geological information generated from the exploratory wells indicate that many Kenyan basins have the necessary characteristics for a commercial discovery.

3.4.7 Supply And Distribution Infrastructure

Petroleum products (fuels, lubricating oils and greases, bitumen etc) are supplied in Kenya by the following;

- KPRL (as a joint government and private venture)
- KPC (as a transporter and storage depots)
- KPA (for import/export jetties)
- KR (as a transporter via railway)
- NOCK (as retailer and explorer)
- Private companies (multinationals and independents as retailers with > 750 outlets)

It is important to note that the bulk (about 90 %) of the petroleum fuels (exports and domestic demand) are handled by the oil pipeline from Mombasa to Nairobi, Nakuru, Kisumu, Eldoret and the Great lakes hinterland. The KPC network is viz, MSA-NBI Line (450 KM); NBI-NKU Line (169KM); NBI- ELD Line (346KM); NBI- KSM Line (345KM). The Eldoret – Kampala extension is to be started soon.

The pipeline presents the most effective, efficient and environmental friendly mode of transportation of such fuels, with the advent of stringent environmental laws in force. To demonstrate this, the minimal losses registered by the pipeline over the last five years were as follows;

Table 3-22: Losses registered by KPC between 1999 and 2003

YEAR	% LOSS
1999	-0.002
2000	0.001
2001	0.005
2002	0.053
2003	0.054

From the above figures it is apparent that the releases via pipeline of the GHG and hydrocarbons that would enter the atmosphere through spills (e.g. tanker and railway tanker accidents) and handling operations is minimal (thanks to SCADA) implying distribution by pipeline to most parts of the country should be enhanced in an attempt to reduce impact of petroleum fuels on climate.

Note:

i. The maximum allowable loss by agreement signed between pipeline and marketers is 0.25 % of petroleum product by volume at 20 °C on a six monthly moving average. The losses covered here include those due to; negligence, pipeline mal-Operations, pipeline breaks, leaks and pilferage.

ii. In order to achieve this, the company has always adopted the cutting edge technologies in as far as its operations are concerned e.g.

- The spirits (MSP, MSR ULG) are stored in floating roof tanks that drastically minimize loss through evaporation and temperature changes.
- The distillates (AGO, IK, JET-A 1) are stored in fixed cone-roof tanks since they're of low volatility hence more economical to keep them thus.
- The tank farm drains are networked via dump tanks and Oil/Water Separators (OWS) to ensure no escape of spilled products to waste or into the municipal foul water systems. This protects the environment (ground water as well as surface waters) upon ensuring maximum recovery of spilled product.
- The product tanks are enclosed in the tank farm with tanks containing spirits and distillates being bunded (dyked) separately with walls to ensure easier product recovery in case of rupture of primary containment.

- The ground bed on which the product tanks are erected is lined with an impervious concrete and polythene material to prevent seepage and contamination of ground water in case of spillage, during the time intervening between spill and recovery.
- The pipeline system fitted with batch and loss monitoring instruments of high precision throughout the line; e.g. transfer meters (PDMs), ENRAF Gauges, SCADA (Supervisory Control And Data Acquisition) system, and daily manual dips.

These are some of the systems that make pipeline operation more environmentally friendly and modern than other transportation modes, hence greatly ameliorates the effects of climate change agents.

3.4.8 Reduction of GHG in Petroleum Fuels Consumption Sector

- Total switch to improved fuel products such as low sulphur diesel and unleaded gasoline. The change process ought to be across board in order to realize the benefits (e.g. the adoption of new products did not incorporate change in device technologies at production level such that the emissions cannot be said to be any better, if not worse).
- End use efficiency improvement by adopting higher efficiency systems.
- Gradual and steady switch to systems that use renewable energies for motive power, lighting heating and other small energy demands.
- Shifting the handling and distribution of petroleum fuels to pipeline system by improving pipeline network in the country.
- Embracing new technologies in product storage that ensure minimal product loss by emission into environment of Volatile Organic Compounds (VOCs).

3.4.9 Natural Gas Import Project

Natural gas reserves were discovered in 1974 offshore Tanzania at the Songo Songo island. Ocelot International Inc. have an agreement with Tanzania for the right to develop, own and operate the gas field and associated generation of electrical power. If piped to Mombasa, the gas can displace imported fuel oil in industry and for thermal generation in Mombasa.

In a recent proposal in October 1999, a consortium of Rolls Royce Power Ventures, Constain Engineering and Construction (Overseas) Ltd. and Skanska BOT Projects A.B submitted a proposal to the Ministry of Energy and KPLC to construct a 110 MW combined cycle independent power plant at Kipevu in Mombasa. The combined cycle plant would require natural gas supplied via a 375-km pipeline from Songo Songo Gas Development in Dar es Salaam, Tanzania. The proposed project if implemented, would deliver the power generated to Rabai substation in Mombasa Kenya.

Construction schedule from Rolls Royce shows that the complete plant can be done in 33 months. A 440km 220 kV double circuit transmission line from Rabai to Nairobi would be needed to transfer the power inland. However, screening indicated the Rolls Royce proposal as uneconomic compared to other alternative generation sources such as geothermal.

Importation of natural gas can substitute fuel oils which have higher emissions. There are short-term plans for conversion of KenGen's 60MW gas turbine to a 120MW combined cycle plant, with assistance from the World Bank. A suitable arrangement for import of natural gas can enable fuel switching for the KenGen power plants. The key factor in this project is making delivery of natural gas to Mombasa suitable for incorporation in the national power development plan. Development assistance in the construction of the pipeline and fuel switching would provide both economic and environmental benefits.

3.4.10 Conclusions on Technology needs Assessment under UNFCCC in the Energy Sector

Energy plays a critical role in the development of the country. The current energy policy objectives emphasize the need for its availability and accessibility at cost-effective prices, and in support of sustainable socio-economic development while protecting and conserving the environment. In appropriating these sources of energy as tools in the development agenda, the Government is in the process of formulating a comprehensive energy development policy and reform programme embracing all sources of energy, especially renewable ones aimed at fulfilling the draft energy policy objectives.

Whereas the amount of energy consumed is an important indicator of the performance of various sectors such as agriculture, manufacturing, and transport, the concept of

using energy consumption, as a measure of performance, in these sectors is not highly rated.

3.4.11 Sectoral Mitigation Technological Options

(a) Transport Sector

The transport sector uses 56% of the petroleum products. Like the energy sector the transport policy is just under preparation. The stakeholders have met to discuss the draft policy. Compared to other African countries in the region the transport sector in Kenya is fairly developed. Issues of environment protection and conservation and energy efficiency are not adequately covered.

The draft policy is divided into four main sub-sectors, namely, Railways, Pipeline, Aviation and Road Transport Infrastructure. The policy also discusses Non-Motorized Transport (NMT) and Safety.

The government has heavy import duty and sales tax on saloon cars and low import duty on smaller cars, motorcycles, mopeds and cycles. This is meant to encourage more members of the society to afford the latter modes of transport, as they are perceived to be more efficient. There is also a policy of restricting vehicle imports and encouraging local assembly of vehicles to only fuel-efficient models. Application of this policy remains difficult and to date there are all kinds (?) of motor vehicles in the market. The government also has a policy of encouraging local assembly to stimulate manufacture of affordable modes of transport. This however remains elusive because many of the locally assembled vehicles are still not affordable by the average citizen who tends to go for second hand imports instead.

A large number of potential GHG emission-reduction options are technically feasible but only some are economically feasible. Some are cost-effective but vary among users, resource availability, know-how, institutional capacity and local market conditions. Energy savings, performance improvements and reduction in private costs also affect their cost effectiveness. These options with potential to mitigate GHG emissions can be generally put into four categories: vehicle technology improvements, including for aircraft and marine vessels; fuel technology improvements, including alternative fuels; non-motorized systems; and infrastructure and system changes. Introducing these options may require justification of other objectives other than GHG mitigation such as competitiveness, security

concerns, and improvement of quality of life or local environment improvement.

Vehicle technology improvements normally involve proper maintenance, improving the engine or vehicle body, or reducing inertia with the main aim of reducing the energy intensity (energy use per useful product) and so reducing carbon emissions. Regular servicing, including regular tyre and oil checks, and engine tuning can lead to fuel savings. Use of three-way catalytic converters along with electronic fuel injecting systems can result in reduction of ozone precursors (unburned HC, CO, $N0_x$) emitted from gasoline cars and heavy-duty vehicles, but the effect on global warming is uncertain because the impact of fuel consumption is also uncertain. Improved combustion by use of gas turbines and low-heat-rejection engines can potentially result in higher efficiency and, thus in lower emissions, but there will be a need for high temperature materials along with compatible high temperature lubricating systems.

(b) Fuel Technology Improvements

Alternative fuels to petroleum include Compressed Natural Gas (CNG); Liquefied Petroleum Gas (LPG); methanol from natural gas, coal or biomass; ethanol from biomass; electricity and hydrogen. The use of these options in reducing GHGs will depend on ease of use, performance and cost.

(c) Non Motorized Systems

Non-motorized transport systems (bicycles, rickshaws, pushcarts etc.) have been used to meet transport needs for urban poor and rural dwellers in developing countries for a long time. Recently, because of its environmental benefits, cycling is seen as an option to meeting the growing demand for urban travel provided its associated infrastructure is available. Cycling can be useful for short urban trips for both passenger and freight trips in cities of developing countries. However, safety is a major problem. Despite this, cycling can be an option if they can satisfy associated infrastructure needs. Studies show that investments in infrastructure needs (dedicated lanes, parking facilities, inter-modal facilities, special signaling) could be recovered between 1 to 4 years with good planning. Walking forms a substantial share of movements in Kenya and many other countries and can be a viable alternative for short distances if the associated infrastructure such as footbridges, attractive and convenient walkways and proper signaling are instituted.

3.4.12 Infrastructure and Systems Changes

Designing clusters under the mixed land model, where homes, jobs and stores are together can reduce trips significantly. However, designing infrastructure to suit transport demands is difficult because of the multiple needs of the different transport modes. Also, an integrated strategy requires coordination between many stakeholders, which is not always easy.

Traffic and fleet management aimed at reducing road congestion and increasing traffic flows for different modes is gaining prominence because considerable energy savings can be realized, resulting in reduction of GHG emissions. Modal shifts from road to rail can yield energy savings and result in GHG reductions.

Increasing occupancy of travel trips by promoting mass public transport systems can result in substantial energy savings and GHG reductions because the emissions per passenger are lower especially with well organized routing and stops. Urban rail systems can prove beneficial in reduction of GHG emissions but experience shows that they are expensive especially for cities with less than 5 million people. The number of tracks also seriously affects its viability.

With a well-developed communication system, use of telephones and telecommuting can assist to reduce travel trips leading to reduction in GHG emissions. As satellite-based communication systems develops, more comprehensive routing of different modes will be possible leading to reduction in GHG emissions.

Some other activities are taking place that will go a long in reducing the emission of greenhouse gas emission. The Agro-Chemical Food Industries at Muhoroni are using Methane from their production process to generate all their steam requirements. This has meant that they no longer use the 12,000 litres of fuel per day as before. The Government of Kenya has also established a Cleaner Production Centre to help industries produce sustainably. Most industries now find it necessary to engage a full time Environmental Health and Safety Officer. It means that very soon most firms will have responsible people to after all activities of environment, including greenhouse gas emission.

3.4.13 Conclusion

Fossil, nuclear and renewable resources are all large in quantity. Future evolution of the world's energy system is less likely to be determined by resource constraints than by active choices made by governments, the private sector, and individuals. The best chance for sustainable development by meeting needs of the present generation without compromising the ability of future generations to meet their needs lies in allowing all energy supply options to compete, improve and contribute on a level playing field directly on the basis of cost effectiveness, environmental protection and safety.

The drive to clean energy supplies would not be so urgent if energy needs were to remain at today's level. But demand will rise substantially, driven largely by demographic and economic growth in today's developing countries.

3.4.14 Way Forward

The creation of the necessary action plan to accelerate the implementation of greenhouse gas emission reduction programme should take into consideration:

1. Analysis and carrying out of the inventory of greenhouse gas emission potential and mitigation options.
2. Enhancement of technology transfer of less greenhouse gas emission technology.
3. Building capacity such as manpower and training, networking, etc.
4. Creating awareness among the public and policy makers on the effects of greenhouse gas emissions.
5. Conducting a study on greenhouse emission reduction policies as input for sectoral stakeholders.

CHAPTER FOUR

4. AGRICULTURE AND CLIMATE CHANGE

4.1 Introduction

The greatest challenge facing Kenya today is to reduce poverty and achieve sustained economic growth for national development. Agriculture in Kenya is the engine for this economic growth and will remain so in the foreseeable future. Consequently sustainable agricultural development is the country's major priority.

The main policy goals for the agricultural sector are to provide food security, raw materials for agro-industry, employment for the rising population and to generate foreign exchange earnings. The following indicators show the dominance of the sector: (i) contribution of 24.0% of GDP (year 2000), (ii) generation of over 60% of foreign exchange earnings, (iii) provision of employment to over 70% of the population, (iv) provision of raw materials to agro-industries which account for about 70% of all industries and (v) provision of over 45% of the annual Government budget.

4.2 Driving Forces and Pressures

Pressures are being exerted on agriculture to feed the rising population, provide employment to rural labour force, provide raw materials to industry, and earn foreign exchange for the country. Much of Kenya's population derives their livelihoods from small holding agriculture. Lack of markets and the very small size of land holdings lead to degradation of the natural resource base which compromises future development.

The root cause of environmental degradation in much of the country is the grinding poverty in rural areas. The poorest people in Kenya live in rural areas and depend heavily on the natural resource base for their livelihoods. These people are often trapped in chronic food insecurity and chronic poverty. They have poor financial and human capital endowments, which limit their ability to invest efficiently to create wealth and climb out of poverty. In the short term, as agricultural productivity declines, the incentive to mine natural resources to sustain their livelihoods makes sense. Over the longer term, the interaction of the biophysical factors of their environment and the economic context leads to a downward spiral. As

land degrades, more marginal land is brought into cultivation, with poor results. Returns to labour are poor and there is no wealth generated. Investment in the resources that sustain farming (soils, water, etc.) is not possible and resources degrade further. The farmers move on to even more marginal land and the cycle begins again, with even poorer results. Ultimately this spiral leads to a situation where the farmer is trapped in chronic poverty and has few options for improving his or her situation. This process also leads to loss of biodiversity including many endemic species.

4.3 The Land Resource in Kenya

Of the total land area of 57.6 million hectares, only 9.4 million hectares are High to Medium Potential Land (HMPL) accounting for about 17% of the total land area. The Arid and Semi-Arid Lands (ASALS) cover over 48.0 million hectares, accounting for about 83% of the total land area of Kenya. Of the 9.4 million hectares of HMPL, 1.1 million ha are occupied by game parks, 2.8 million ha are cropland, 2.8 million ha are grazing land (mostly dairy), 2.0 ha million are forested and 0.5 million ha are covered by urban centres, homesteads and other infrastructure. Nine million ha of the ASALs can support some form of agriculture, 15 million ha is just adequate for livestock raising and the remaining 24 million ha is dry and suitable for nomadic pastoralism.

The HMPL has the potential to be the breadbasket of Kenya. However, productivity in these areas is declining despite the growing demand for food and other agricultural products. Soil erosion, loss of soil fertility, flooding and loss of biodiversity are increasing in all areas. Water scarcity and conflicts over it is also limiting production in some areas, especially during the dry seasons. Due to population pressure in the HMPL, sub-division of land has resulted in small uneconomic farm sizes, which cannot be run sustainably.

4.4 Fertilizer use in Kenya

Commercial farming is growing in Kenya and is providing both employment opportunities and foreign exchange earnings for the country. Kenya currently consumes about 300,000 metric tons of inorganic fertilizer material per year, containing about 120,000 metric tons of nutrients, mostly on commercial farms. Fertilizer use on smallholder farms is limited. Fertilizer sales are worth US$ 85 million of business. However, current fertilizer usage is well below its potential. Consumption could exceed one million metric

tons of fertilizer material or 400,000 metric tons of nutrients worth US$265 million of business.

It should be pointed out that the majority of the over 3 million smallholders use little or no fertilizer. The estimated 15% who are able to apply fertilizers do not actually use the recommended amounts for a number of reasons. First, current fertilizer recommendations are applied as one size fits all for each region in Kenya. Farmers do not always receive the expected yield gains from fertilizers because soils are depleted of organic matter and productivity is limited by other factors than nutrient availability. Secondly, fertilizer packaging is not appropriate for smallholder farmers. A 50Kg bag of fertilizer costs about one month's wages of a smallholder farmer. Several efforts have been made at repackaging fertilizers for sale to smallholders, but there have been problems with adulteration. However, there are several examples of successful small packaging efforts, like the Mavuno experience in Western Kenya.

Out-grower schemes have been successful at promoting fertilizer use on smallholder farms, primarily in the sub sectors of tea, sugar, and coffee. One means of empowerment of smallholders is through improvement in governance of farmer organizations, which provide greater benefits to the smallholder by exploiting economies of scale through bulk purchases.

4.5 Restoration of Soil Fertility

Restoration of soil fertility must go hand-in-hand with sustainable rural development strategies. Much of rural Kenya requires significant investment in the restoration of soil fertility. For example, a recent analysis suggests that more than 70% of the soils in the Nyando River Basin have nutrient limitations. The same is true for much of Western Kenya. Use of fertilizer trees, soil conservation, erosion control and nutrient recapitalization are important activities towards restoring soil fertility. Sustainability requires an approach that integrates activities such as agroforestry, improved tillage practices, soil conservation and livestock production to bring about improved soil fertility and increased agricultural production.

Local community understanding and commitment to the development process is essential. Community driven projects need to be developed that empower smallholder farmers to

take charge of their future. Projects need to be set up in communities and local institutions strengthened so that lessons learned during implementation can be rapidly scaled up to reach the large numbers of people who are trapped in poverty and who suffer from food insecurity.

4.6 Pastoralists and small-scale livestock production

Pastoralism is an important economic activity in the ASAL areas and improvement in livestock production and marketing represents a principal means of alleviating poverty and reducing vulnerability to climate variation in these areas. The introduction of fodder banks and improved water management will be key elements of an adaptation strategy in these areas. Dairy and Poultry development are other smallholder activities, which could be supported in the more humid areas of the country. The improvements in the control of animal diseases and nutrition are essential in order to facilitate marketing and stock movements. Increased use of high quality legume forage, like *Calliandra*, as protein supplements can be instrumental in maintaining herd health during dry seasons and droughts. The capacity of the private sector to deliver veterinary services needs to be developed. There is need to promote the domestication and use of the many indigenous fodder trees and shrubs, and capture the enormous traditional knowledge on them among the communities in the drylands.

4.7 Opportunities for research and extension

Research and extension have a strong role to play in facilitating adaptation to climate change in the agricultural sector. Research has become more participative in Kenya over the past two decades and this trend needs to continue. Farmer participation in the research effort is needed to ensure that solutions developed by scientists are appropriate to the constraints felt by farmers and to promote faster uptake of new technologies and practices by farming communities. Participation in research activities will strengthen the adaptive capacities of participating communities.

Agricultural research services and universities will need to contribute by producing relevant knowledge and training Kenyan professionals. New crop varieties and improved livestock breeds will be needed, improved pest and disease management will be required to help farmers cope with changes in pest and disease distributions. Improved farming systems will be needed to help farmers cope with biophysical changes as well as market changes that will be brought about by changing climates. Increased use of

agroforestry in farming systems, particularly in the ASALs can play an important role in reducing vulnerability of rural populations. A key element in the adaptation strategy of Kenya needs to be the application of an ecosystems approach to natural resource management. Rural farmers need to be recognized as ecosystem managers and in that sense, agricultural development planning needs to be integrated into natural resource management planning.

There is a significant research agenda in the application of the ecosystems approach to environmental management. New tools are needed to assess the state of natural resources. New technologies are needed to help farmers better manage their resources. New planning approaches are required to ensure participation of rural communities in development planning.

Generation of new knowledge is not sufficient for successful adaptation. Stronger linkages between policy makers, extension services, farmers and research agencies are critical for effective information dissemination and application. Currently there are both public and private sector extension services providers. Public sector extension services can be found in the Ministries of Agriculture, Livestock and Fisheries Development, Water Resources Management, Cooperative Development, Social Services. This, combined with NGO's and other private sector actors including religious based and community based organisations, suggests that there may be a critical mass of extension agents available to bring about the needed transformation in Kenya's rural areas, but we need to redynamise these services. The Ministry of Agriculture has developed the policy framework to guide this activity. Similarly, there are both public and private agricultural research providers who are continuously updating technology on various fields. NEMA is taking a coordinating role between the different ministries to ensure better service delivery to communities.

One of the approaches to service provision is Farmer Field Schools (FFS). Since 1995, when it was first introduced in Kenya, the FFS approach has been tested and adapted to a wide range of crop and livestock enterprises. As of March 2003, about 1,500 FFS had been implemented in Kenya in 23 districts reaching about 34,000 farmers will support from IFAD, UNDP, FAO, DFID and a wide range of NGOs and local institutions. There are a number of other approaches that have been successful including NALEP. The system of direct funding to farmers groups for payment of extension services

has dramatically improved performance of extension delivery and accountability of extension providers. A new development to reduce the costs of FFS implementation is to provide resources on a cost-recovery basis, which poses the challenge of establishing adequate institutional capacity to manage such revolving funds.

One area that we would like to single out is the need for greater focus on input delivery and produce marketing in farmer training initiatives. Kenya should support emerging apex organizations, extension networks and farmer organizations in their efforts to provide services to their members.

4.8 Impacts of Climate Change on Agricultural Productivity

In Kenya, where agriculture is largely rainfed, productivity depends largely on agro-ecological factors and in particular on rainfall. Other factors such as temperature, soil characteristics and the use of production input factors such as fertilizers and chemicals are also important for determining agricultural output. Climate change arising from the build-up of greenhouse gases provides a profound challenge for the future of agricultural production. Climate change impacts will vary based on locality, but the probability of disruption of Kenya's agricultural sector is very high.

Predictions are not sufficiently detailed at this point to provide secure guidance for adaptation strategies. A number of modelling exercises suggest that the highlands of Kenya are likely to get wetter, while the ASALs are likely to get drier. One thing we can say with relative certainty is that the climate is likely to become more variable. Kenya can expect more droughts and more floods than it has seen in the past, and planning for this situation is wise.

There are a number of impacts that we can identify at this point and we understand their implications for the changes we are likely to see in the near future.

- A decrease in rainfall in the ASALs would increase the total area of the country under arid conditions. This has the potential disrupt agro-pastoral production systems and cause severe food insecurity in the event of droughts that would create water stress for both crops and livestock. Desertification would be intensified as vegetation cover deteriorates and soil erosion accelerates

- A rise in temperature associated with increase in rainfall amounts in pastoral lands would have positive effect on pastures, hence livestock conditions, and arable crops in the same localities.

- In the high potential areas, (agro-ecological zones I-IV) a rise of temperatures without corresponding increase in rainfall may predispose agriculture to increased levels of pests (such as aphids). Crop fecundity could decline requiring the development of new crop varieties.

- A corresponding increase in rainfall in the high potential areas would, however, have mixed results; landslides on steep slopes, floods, increased maturation period for crops, increased incidence of fungal diseases in potatoes, maize and beans.

- In the coastal areas, it is predicted that climate change would cause loss of biodiversity, siltation and salinization of agricultural land and change time of harvest.

4.9 The adaptation challenge

The challenges of adaptation will be significantly affected by the manner in which climate change effects are experienced. However, there is no denying the need for looking forward and including adaptation measures into rural development planning. The best way to reduce the vulnerability of smallholder farmers is through sustainable development and poverty reduction.

We know that future effects will include increases in short-term weather extremes. Extreme weather events already severely challenge the ability of farmers to secure their livelihoods. Improved technology transfer such as more reliable long-term weather forecasting will contribute to reducing current vulnerability of poor and food insecure rural households and will be critical to their ability to adapt to future changes.

The drought, which was experienced between October 1998 and May 2001, was so severe that the Government declared it a national disaster on 13th June 2000. The limited availability of pasture caused animals to feed on roots of shrubs to survive and concentrate on small grazing grounds. Their movements in search of water and pasture caused land degradation, increased water and wind erosion at the onset of the rains. Up to 80 percent of livestock died in some arid and semi-arid areas with devastating effects on the pastoral communities. To save the remaining animals, pastoralists took their animals to urban areas and to Mount Kenya where some of them died of pneumonia as well as high-altitude tick fever. On the crop sector, many farmers used seed stocks for food, thus reducing the amount available for planting the following season. Crop yields decreased considerably and in several districts, there were no harvests.

The potential for autonomous adaptation depends on affordability and availability of such measures, which include changes in crops and crop varieties, improved water management and irrigation systems, and changes in planting schedules and tillage practices. Most of these adaptation opportunities are being applied by farmers where there is access to the right information and tools.

However, a large section of the population is constrained by issues such as lack of awareness, poor soil quality, low water availability economic, technological, institutional and even cultural barriers. These sorts of barriers will limit autonomous adjustments. There is a strong need for support to research and extension services to ensure that adaptation options are developed.

Investing in soil health is an important area that requires support for facilitating adaptation to climate change. Soils are one of the primary resources upon which agricultural productivity depends, and it is a key resource that is rapidly degrading in parts of Kenya. There are a number of technologies available that can be applied to facilitate rehabilitation of degraded soils that will contribute to adaptation to climate change. Table 4-1 summarises some of these options and the actions required to integrate these technologies more widely in Kenyan agricultural systems. The table does not provide an exhaustive list.

Table 4-1: Intervention for Increasing Agricultural Productivity that Contribute to Reducing Vulnerability of Farmers to Climate Change.

Options for improving soil health	Contribution to climate change adaptation	Action
Chemical fertilizers	Fertilizers reduce vulnerability of crops to mid-season droughts.	▪ Ensure timely availability ▪ Ensure affordable costs ▪ Appropriate packaging ▪ Ensure against adulteration ▪ Ensure efficient distribution ▪ Develop local rock phosphate deposits ▪ Improve extension services to farmers
Fertilizer trees	Fertilizer trees supply nutrients and improve soil structure, water holding capacity and other properties that increase plant available water	▪ Identify appropriate species ▪ Identify niches on farms in different regions ▪ Provide mycorrhiza & rhizobia inoculums, when needed
Green Manure	Green manures are sources of nutrients and organic matter. Green manures can reduce vulnerability to drought by enhancing fertility, thus promoting early crop growth and by enhancing infiltration and soil water holding capacity. These systems have been implemented widely in vegetable production. Some have also fodder value. The resultant manure from livestock can be a rich source of nutrients for crops	▪ Identify appropriate species ▪ Identify niches on farms in different regions ▪ Support seed production and distributions systems
Improved Crop residue management	Returning crop residues to fields can help reduce P and K deficiency in crops. It can also improve soil organic matter content. Both of these can reduce vulnerability to droughts	▪ Recycle crop residues to farms and discourage burning them ▪ Reduce dependence of cattle on crop stover by developing alternative feeds

Options for improving soil health	**Contribution to climate change adaptation**	**Action**
Mechanization	Mechanization allows for improved contour ploughing and construction of water retention structures that can reduce vulnerability to droughts.	▪ Promote increased use of appropriate mechanization ▪ Promote local manufacturing of agricultural machinery
Rural Credit	Increasing the availability of credit in rural areas can promote investment in more sustainable technologies	▪ Expansion of micro-credit experiences ▪ Subsidies of rural credit schemes ▪ Building the capacity of rural communities and institutions to manage and pay back credit provided
Soil Erosion Control	Reducing soil erosion will help ensure a reasonable harvest in both wet and dry years	▪ Promote awareness among farmers ▪ Disseminate appropriate technologies ▪ facilitate terrace building and water management in sloping lands
Conservation tillage	Conservation tillage allows for better conservation of soil organic matter. This enhances water holding capacity and buffers against droughts. In some areas, this technique requires increased efforts for weed control	▪ Research – performance of this technique is not fully understood in African agricultural systems ▪ Raise awareness ▪ Disseminate technology and document and support adaptations by farmers ▪ Form and support conservation tillage associations

Options for improving soil health	Contribution to climate change adaptation	Action
Improved striga control	Striga is a parasitic weed of maize and millet. As climate shifts, the range of striga infestation may expand. A number of approaches have been developed including the push-pull system and improved fallow systems, which can reduce striga virulence.	▪ Dissemination of current control mechanisms ▪ Development of improved control mechanisms, particularly as the weed infests new areas. ▪ Developing and disseminating crops tolerant to striga
Fodder banks	Fodder banks provide high quality fodder during droughts and dry seasons to pastoralist herders while improving soil quality.	▪ Research – opportunities exist to expand the species choices in African drylands ▪ Raise awareness ▪ Disseminate technology ▪ Develop technologies for preserving excess production during the rainy season for dry season feeding

4.10 Climate change mitigation and adaptation options for agriculture through technology

There are many opportunities for synergies between adaptation to climate change and mitigation of the causes of climate change (see box). The country has recognized that it is in her national interest to implement her commitments under the United Nations Framework Convention on Climate Change (UNFCCC). However, this will not be possible without the effective implementation by other parties of their commitments under the convention related to financial resources (Article 4.3) and transfer of technologies (article 4.5). Technology transfer becomes very pertinent in this regard. However, assessment of technology needs, including capacity building needs, information systems for technology transfer and cooperation, creating an enabling environment, capacity building and enhancement and implementation support mechanism are very vital for successful local adaptation.

Mitigation of climate change refers to activities that contribute to reducing the load of greenhouse gases in the atmosphere. These activities can either reduce emissions or remove greenhouse gases and sequester them in ecosystems. Through the Kyoto Protocol, there are mechanisms to facilitate development in Kenya to ensure that Kenya follows a cleaner development pathway than would otherwise be possible. The advantage for Kenya to utilize this opportunity is that she will be less dependent on fossil energy, which will become scarcer and more expensive over the next several decades.

Carbon sequestration projects involve activities that increase carbon stores in terrestrial ecosystems, including agroecosystems. Activities such as tree growing, reduced tillage farming, ecosystem restoration, and soil conservation all increase carbon stores in ecosystems. Today there are financial mechanisms, both within the Kyoto Protocol and in the informal climate sector to help finance these activities. The advantage to Kenya of participating in these is that additional funds can be made available through these mechanisms to facilitate sustainable development.

Mitigating and abatement options through improved agricultural technology should address the following:

(i) Increasing opportunities for adaptive management practices that reduce land degradation, including the following:

- Improved tillage methods and cropping;
- Increased and better use of fertilizers and organic nutrient sources;
- Wider application of soil erosion control;
- Improved use of agro-chemicals;
- Diversification of cropping systems;
- Intensification of agricultural production;

(ii) Addressing inadequacies of existing crop varieties to adapt to changing agriculture in the face of a more variable climatic regime;

(iii) Wider application of an ecosystem approach to managing agricultural landscapes;

(iv) Declining soil fertility due to lack of access to agricultural inputs;

(v) Inadequacies in information flow between research,

extension and farmers to enhance the adoption of appropriate technologies for improved agricultural production;

(vi) Declining agricultural biodiversity, including indigenous vegetables, which provides the resilience of agroecosystems to changing climatic patterns;

(vii) Opportunities to facilitate better use of seasonal weather forecasting by farmers to ensure that variety/cultivar choice and fertilizer application better match rainfall expectations.

Adaptation to climate change involves moving to sustainable farming systems and sustainable livelihoods for Kenya's farmers. Much of what is needed is sustainable rural development. Climate change will add additional stresses onto an already much stressed system. There is a need to diversify rural economies, invest in infrastructure (grain storage, electricity, roads, markets, etc.), improve farming practices, and create market opportunities. In many situations, Kenya does not require the transfer of technology from the north to the south. What is needed is investment in rural development. Sustainable farming practices will produce more resilient farming systems. Technology has a role to play in creating more sustainable management options, but technology alone is not the answer. Technology needs to be embedded in a more holistic ecosystem management approach to managing rural landscapes. Table 4-2 gives examples of Kenya's technology requirement for improving agriculture and reducing vulnerability of farmers to climate variability and climate change. Those technologies that have both high impact on farmer vulnerability and climate are the win-win options for Kenya. The win-win options that have low cost are the highest priorities for immediate action.

Table 4-2: Summary of the types of synergistic technologies that could be developed in Kenya to reduce vulnerability of farmers and contribute to reduction in atmospheric loading of greenhouse gases. The priority win-win options are shaded.

Objectives	Technology	Potential Vulnerability Impact for Farmers	Potential climate impact	Relative Cost
Rehabilitation of degraded soils	Conservation Tillage	High	High	Low
	Replenish soil organic matter	High	High	Low
	Terracing	High	Medium	High
	Contour hedge rows	High	High	Low
Better water management	Improved Irrigation	High	Low	High
	Water harvesting	High	Low	Medium
Improve agronomic practices	Improved varieties	High	Medium	High
	Integrated pest management (IPM)	High	Low	Low
	Fertilizer trees	High	High	Low
	Cover crops	Medium	Medium	Low
	Inorganic fertilizers	High	Negative	High
	Improve nitrogen efficiency	Medium	Medium	Medium
Improve animal agriculture	Improve feed efficiency	High	Medium	Low
	Improved breeds	High	Low	Medium
	Fodder banks	High	High	Low

Objectives	Technology	Potential Vulnerability Impact for Farmers	Potential climate impact	Relative Cost
Production diversification	Fruit and nut trees	High	High	Low to Medium
	Cultivate gums and resins in drylands	High	High	Low
	Cultivate woodlots	High	High	Low
	Macadamia shade trees over coffee	High	High	Low
	Other agroforestry production systems	Medium to High	High	Low to medium

There are a number of constraints to adoption of new technologies by farmers. Table 4-3 presents a number of examples of barriers to technology dissemination, but this list is not exhaustive. The types of barriers can be grouped into:

- Financial barriers
- Labour barriers
- Market barriers
- Cultural or social barriers
- Knowledge barriers

Table 4-3: Examples of the types of constraints to wider adoption of promising technologies.

Technology	Constraints
Irrigation	▪ Requires large investments and national technology and assessment commitment; ▪ Labour requirements are high; ▪ Requires training at the farm level; ▪ Requires cooperative community action;
Water harvesting	▪ Lack on knowledge of water harvesting techniques; ▪ Cost of materials; ▪ Increased labour demands;
Direct seeding of rice	▪ Requires intensive weed control; ▪ Agronomic knowledge;
Substitution of traditional varieties by improved varieties	▪ Less preferred grain quality; ▪ Past problems with improved varieties in certain areas have influences farmer perceptions negatively; ▪ Management changes required;
Conservation Tillage	▪ Risk of yield reduction; ▪ Different tool needs; ▪ Need selection of crop varieties that work well with the technology; ▪ Requires intensive weed control;
Ammoniation of straw for animal feed	▪ Ammonium sulphide is more expensive than urea;
Wider adoption of agroforestry technologies	▪ Tree seed availability; ▪ Farmers require training in agroforestry technologies from extension services; ▪ Lack of markets and market information; ▪ Land and tree tenure constraints;
Rehabilitation of degraded soils	▪ Requires capital investment, with delayed returns; ▪ Knowledge of conservation options; ▪ Land and tree tenure constraints;

Technology	Constraints
Biogas generation	▪ Requires investment; ▪ Marketing knowledge; ▪ Labour constraints;
Fodder banks	▪ Tenure and usufruct rights – pastoralists are mobile; ▪ Lack of tree planting culture in pastoralist communities; ▪ Lack of tree planting knowledge in pastoralist communities; ▪ Seed availability;
Cultivation of gums and resins in drylands	▪ Lack of knowledge about cultivation and harvesting of gums and resins; ▪ Lack of market knowledge; ▪ Tree tenure and usufruct rights constraints; ▪ Seed availability;

4.11. Climate change mitigation and adaptation options for agriculture through environmental service projects

Environmental service projects are a relatively new concept and there is only limited experience with these types of projects in Kenya. In these projects, farmers and land managers are compensated for improving management practices that generate off-site benefits. For example there are a number of schemes in watershed management projects in Latin America and South Asia, where upstream farmers are compensated by downstream water consumer for adopting more sustainable management practices that reduce sediment loads in rivers.

The Clean Development Mechanism (CDM) of the Kyoto Protocol offers new opportunities to gain experience in these types of projects. Through the CDM, farmers could be compensated for adopting agro-forestry and forestry activities that result in carbon sequestration in agricultural landscapes.

(i) The role of agro-biodiversity

Maintaining agro-biodiversity is an important part of the climate change adaptation strategy. Technologies on proven and accepted traditional farming systems, conventional breeding, or new biotechnology applications appropriate to the Kenyan situation could be used to maintain local/indigenous plant and animal genetic resources which are the foundation of sustainable agriculture and food

security. Genetic diversity in agriculture enables plants and animals to adapt to new pests and diseases, changing environments and climate. Technology transfer for improved *ex situ* conservation of local/indigenous plant varieties and animal breeds, and capacity building to effectively use such technologies are, therefore, very necessary.

(ii) Rural Income and Nutrition

Adaptation to climate change and sustainable development in rural Kenya will require an integrated approach to poverty alleviations. Improvement in rural incomes and nutrition are key elements in improving family economic and physical health. Table 4-4 provides a summary of interventions and actions for improvement of rural income and the rural agricultural sector.

Table 4-4: Summary of problems and actions to increase rural incomes and enhance nutrition.

Problem domain	Issues	Action
Storage	▪ High storage losses (>30%); ▪ Quality and quantity maintenance;	▪ Promotion of communal storage; ▪ Proper control of storage pests (chemical, organic pesticides);
Processing, packaging and food quality	▪ Short shelf-life; ▪ Deterioration in quality; ▪ Pest attack; ▪ Low value /prices;	▪ Cottage industries; ▪ Infrastructure (water, power, machinery); ▪ Establishment of quality standards;
Income from Livestock	▪ Low income due to marketing problems; ▪ Disease problems;	▪ Improvement of marketing infrastructure; ▪ Promotion of small stock and poultry; ▪ Promotion of distribution of breeding material;
Fisheries	▪ Low exploitation of fish as a rural income earner; ▪ Localized consumption; ▪ Short shelf-life (high perish-ability); ▪ Poor quality vs. international standards;	▪ Promotion of rural fish farming and consumption; ▪ Promotion of processing and packaging products; ▪ Promotion of cooling plants;

Problem domain	**Issues**	**Action**
Crops	▪ Poor producer prices; ▪ Low quality produce; ▪ Inadequate marketing information; ▪ Low quality vs. international standards; ▪ Low productivity; ▪ Poor governance of farmers organisations;	▪ Promotion of competitiveness through quality improvement; ▪ Improvement of management of farmer organisations; ▪ Promotion of production; through technology adoption and up-scaling; ▪ Promotion of enterprise diversification; ▪ Increased access to inputs through organization of input distribution and markets;
Markets	▪ Poor marketing infrastructure (facilities); ▪ Poor access to market information;	▪ Improvement of market infrastructure (water, cooling, shelter etc); ▪ Improvement of ICT; ▪ Formation of marketing associations;

Problem domain	Issues	Action
Improving nutritional outcomes	▪ Inadequate nutrition (quality and quantity) for various categories of people under different circumstances;	▪ Expansion of community-based nutritional programs to reach more people & improve diet; ▪ Greater coverage of school meals programme; ▪ Promotion of dietary diversification (include new dietary; items)associated with production diversification ▪ Expansion of fortification of foods for vulnerable groups; ▪ Improvement of delivery of food aid in emergency situations; ▪ Promotion of food and cash for work;
Vulnerable groups Street people Orphans Refugees Internally displaced Widows (widowers) Immigrants	▪ Inadequate nutrition (quality and quantity); ▪ Inability to produce; ▪ No land for production; ▪ Low resource endowment;	▪ Rehabilitation of street people; ▪ Provision of employment opportunities; ▪ Food aid; ▪ Food/cash for work; ▪ Resettlement; ▪ Peace initiatives; ▪ Legal reform and enforcement; ▪ Review and enforcement of succession law;

4.12. Conclusion

Of all of the human enterprises, agriculture is the most dependent on climate. Current climate variability puts huge stress on agriculture, particularly in the smallholder sub-sector. Future increased climate variability and

climate change will add more stresses to the sector as a whole. Much of the industrialized portion of the sector has the means to deal with the climate variability through irrigation, but the smallholder portion of the sector will be particularly vulnerable.

To be successful, adaptation planning cannot be undertaken as a separate exercise from other planning processes in Kenya. "Mainstreaming" climate change planning into other planning processes is the key to successful adaptation and limiting the negative effects of climate change. For example, the anticipated effects of climate change need to be factored into poverty reduction strategies and rural development strategies.

In this chapter, we have outlined a number of opportunities to reduce the vulnerability of smallholder farmers. Many of the recommendations are not specific to climate change and make good sense from a sustainable development point of view. Those that can be accomplished at low cost, but that have high impacts represent the highest priorities for short-term action.

Successful rural development and successful adaptation to climate change need to be implemented through an integrated ecosystems approach to agriculture and natural resource management. Environmental services projects such as the Clean Development Mechanism offer opportunities to gain experience with these integrated types of projects.

CHAPTER FIVE

5. FOREST SECTOR AND CLIMATE CHANGE

5.1. Introduction

Forests can be vital a safety net, particularly during years where crops fail, helping rural people to avoid or rise out of poverty (FAO 2003). The contribution of forests to poor households is largely unrecorded in national statistics, as most of it is for subsistence or for trade in local markets.

Table 5-1 below shows vegetation and land use cover in Kenya. Woodlands, bushland and wooded grasslands occupy 65.1% of the total land in Kenya. However, available information on conservation and management is mainly restricted to closed canopy forests. What this means is that there is urgent need to examine the status of the 65% that is classified as bushland, grassland and wooded grasslands.

Table 5-1: Summary of vegetation cover of Kenya

Type of vegetation	**% of total area of Kenya**
Indigenous forests	2.1
Plantation	3.0
Woodland	3.7
Bushland	42.9
Mangrove	1.0
Wooded grassland	18.5
Grassland	2.1
Desert	13.7
Farmland and urban development	16.5
Total	**100.0**

Source: (Forest Department)

Population increase and the increasing demand for land are among the forces propelling forest conversion. In Kenya the land that is not suitable for cultivation is largely used for grazing livestock. Future demand for food will

have to be met through more efficient use of existing agricultural land. Some land-use options such as agroforestry, tree crop plantations and scattered trees on farmlands can potentially assist in poverty alleviation while conserving forests.

Kenya presents striking contrasts. Over the years, closed canopy forests have been destroyed and their area reduced from 3% to 1.7% of the total land area since independence. At the same time, key economic sectors, including cash and subsistence crop production, tourism and energy generation, have increasingly relied on the environmental services provided by our shrinking forests.

Kenya's closed canopy forests (Table 5-2) are estimated to cover about 2% of the country (Wass, 1995). These are forests that are climatically restricted to central highlands and the Nyanza plateau in areas below an attitude of 3,000 metres. The exceptions to this geographically limited area are forestlands occurring on top of inselberg structures in the lower parts of the country, riverine forests and forests in narrow coastal belt within rainfall over 1,000mm.

Table 5-2: Breakdown to forest area of Kenya by type

Forest Type	**Area Ha**	**% of total closed canopy forests**
Indigenous forest	1.24 million	88.5
Plantation forests	0.16 million	11.5
Total	**1.40 million**	**100.0**

Source: (Forest Department)

5.2. Loss of Forest Cover.

Kenya loses at least 5,000 hectares of forestland annually through excisions. This loss is a combination of plantations and indigenous forests within the forest reserves, and does not take into account what happens on forest cover outside gazetted forests. Most excisions have been conducted without consultations or debate as the law requires. During the last decade, the estimated country's loss of gazetted forestland is 125,405ha. Of this 109,685.4 ha of indigenous forest and 15,719.6 ha of plantations have been lost.

Within the same period a total of 45,000 ha of mature plantations have been clear felled and only 20,000 ha has been replaced with growing stock. The rest of 25,000ha is either under fallow or crops.

The basic causes of forest cover loss stems from a growing demand for land and for forest products. Kenya has inadequate capacity to implement sustainable forest management as a result of economic, social and institutional constraints. Excisions, encroachment, wildfires, overgrazing and charcoal burning and drought have all undermined the forest resource base. Charcoal burning and overgrazing have particularly been a problem in the arid and semi-arid areas.

The continued deforestation and degradation has not only contributed to loss of biodiversity and wildlife habitat but has also negatively impacted on the environment and the economy in terms of reduced dry season base-flow in streams and rivers, reduced energy generation capacity, increased incidences of flash floods, and siltation. Deforestation and forest degradation also cause the release of carbon which contributes to the atmospheric burden of greenhouse gases.

Increasing pressure on land suggests worsening of land degradation, especially in the context of very limited investment on land and water management. Almost 80% of the land in Kenya comprises arid and semi-arid land and most of it suffers from degradation on the account of poor land use practices, loss of soil fertility, overgrazing and exploitation of tree resources with very minimal chances of regeneration.

5.3. Factors Affecting the Forest Sector

Forestry in Kenya is affected by many factors, most of them external to the sector (Table 5-3). It is important to understand how they influence the multitude of actors whose actions directly and indirectly affect forests. These factors generally fall into two broad categories; those that affect forests and forestry directly, such as demographic, economic and technology changes, consumption etc.; and those that are fundamental but harder to measure, such as political and institutional changes and most importantly, overall changes in society including its values, attitudes and perception.

Table 5-3: Impacts of stress factors on forestry in Kenya

Stress factors on forestry sector	Impacts
Population Pressure and Poverty	▪ Excessive and uncontrolled extraction of forest products for commercial and subsistence use; ▪ Inefficient utilisation of forest products; ▪ Degradation through encroachment for agriculture ▪ Excision for settlement and other developments; ▪ Overgrazing;
Limited technological capacity	▪ Inefficiencies in a number of areas in forest management: ▪ Resource assessment and inventory; ▪ Harvesting and processing; ▪ Forest and plantation management;
Institutional limitations	▪ Lack of coherence due to different agencies managing different types of forest; ▪ Weak linkages with MENR, KEFRI and civil society; ▪ Poor frameworks for integrating populations living near forest reserves into management planning; ▪ Forest management follows administrative boundaries which results in fragmentation of ecosystems; ▪ Many forests are virtually unmanaged and communities harvest forest products in uncontrolled ways;
Excisions in gazetted forest	▪ Loss of biodiversity; ▪ Loss of watershed function; ▪ Difficulties in implementing forest management plans;
Poorly regulated harvesting in natural forests	▪ Loss of biodiversity; ▪ Highgrading; ▪ Poor harvesting practices damage the residual stand; ▪ Soil erosion;

Stress factors on forestry sector	Impacts
Poor plantation management	▪ Growing stock is decreasing because harvesting rates exceed planting rates; ▪ Bans on harvesting have the unintended effect of halting other silvicultural operations like thinning and pruning; ▪ Resulting overstocking results in poor quality timber, slow growth rates and exposes plantations to risks from windthrow;
Difficulties in managing fire	▪ Forest resource degradation; ▪ Loss of important biodiversity areas;
Land tenure	▪ Insecure land tenure is a constraint to tree planting on private lands
Conflicts between humans and wildlife	▪ Human settlement has encroached on wildlife migration pathways, which, in the case of elephants, can lead to forest destruction when movement is blocked;

Since independence (1963), the population of Kenya has grown three fold, leading to increasing the demand of forest products and services as well as need for more land for agriculture. As the majority of the gazetted forest reserves are concentrated in the medium to high rainfall areas of the country, where the population is concentrated, there is bound to be conflict over land. Populations living adjacent to these forests suffer from high levels of poverty and in some cases many people are landless. Because of poverty, these people turn to forests as a means of earning their livelihood by extraction of forest products for subsistence use and local trade, encroachment for agriculture, over abstraction of water for irrigation and poaching of game for meat.

Population growth without commensurate economic development is the main cause of perpetual poverty in most of the developing countries. Poverty is one of the forces propelling land degradation as a resort of heavy dependence on tree and forest resources which in most cases are available for free. According to FAO (2003) extreme poverty and environmental degradation in most countries in the East African Subregion will remain the key problems in the next two-decade. Poverty alleviation and environmental protection are expected to remain the main objectives of social and economic development.

5.4. Additional Stress on Forests From Climate Change

The preceding section makes the point that the forestry sector in Kenya is stressed and is unlikely to be able to meet the wood and fibre needs of the Kenyan population in the long-term. Climate change is likely to add additional stresses to this system.

In natural forests, climate change may alter the fitness of individual species and cause either species migration or extinction. The degree of the impact will vary by species and by region. For example, on Mts. Kenya and Elgon, many species will likely be able to migrate up slope as temperature increases and as rainfall patterns shift. In areas where the forest is highly fragmented, such as western Kenya, species migration is likely to be difficult.

One of the great unknowns at the moment is how climate change is likely to affect the distribution and virulence of tree pathogens and pests. There are a number of worrying pest and disease problems on the horizon, which could become worse as climate change (see box).

5.5. The Contribution of Forests to the Adaptation Challenge

The challenges of adaptation will be significantly affected by the manner in which climate change effects are experienced. However, there is no denying the need for looking forward and including adaptation measures into forest development planning. In forestry adaptation has a double meaning. Better forest husbandry can contribute to helping rural communities adapt to climate change. At the same time, as we noted above, climate change will introduce additional stress into forest systems. Thus Kenya needs to facilitate adaptation of the forest ecosystem to climate change.

As chapter 4 indicated, climate change will likely have negative impacts on rural populations in Kenya. This will also likely increase the pressure from these populations to draw upon forest resources for their livelihoods and help buffer them against climate shocks and other constraints.

Extreme weather events already severely challenge the ability of farmers to secure their livelihoods. If forests

are seen only as sources of goods (wood, fruits, etc.) and not as sources of services, it is likely that populations will continue to degrade forest resources. Forests need to be appreciated by rural populations for the services they provide. For example, forests play an important role in water retention on the landscape during heavy rain periods. Continued deforestation of catchments will lead to more severe flash flooding during these events, creating further hardship for populations in the lower reaches of catchments. Table 5-4 outlines a number of options and actions for improving the use of forests to facilitate adaptation. Opportunities for creating synergies between adaptation and mitigation need to be explored through the Clean Development Mechanism.

Table 5-4: Forestry Intervention for Reducing Vulnerability of Farmers to Climate Change.

Adaptation Options	**Contribution to climate change adaptation**
Ecosystem approach to land management	Treating the landscape as a whole and devising management strategies based upon the ecosystem and how it fits into the landscape is essential for integrating forest management with management of other natural resources. An ecosystems approach also offers opportunities for integrating the adaptive strategies to maintain the integrity of forest ecosystems as climates change and to facilitate wise use of forest resources to contribute to the livelihoods of rural populations as they adapt to climate change.
River basin rehabilitation	Many of Kenya's river basins have suffered from land and ecosystem degradation and loss of tree cover. As water availability becomes more variable, improved management will be required to ensure supply of safer drinking water to rural populations. Management of river basins need to be undertaken holistically. Deforestation at the upper reaches of fiver basins cause problems downstream.
Restoration and sustainable management of riparian forests	Riparian forests and wetlands are important for improving water quality and for storing water for use by upland populations. As climate becomes more variable, these ecosystems are particularly important for reducing the severity of floods. Loss of these ecosystems often leads to severe erosion in the lower portions of catchments.

Adaptation Options	**Contribution to climate change adaptation**
Agroforestry for wood and non-wood product production	Agroforestry can buffer farmers against climate shocks. Trees often produce during years when crops fail, for a number of reasons. Trees can also be a fall-back and can be harvested when income from cropping is not sufficient to meet family needs.
Medicinal tree planting programmes	As climate change exerts more pressure on forest ecosystems to provide goods and services, this pressure needs to be reduced by transferring the provision of some of these services outside of forests. Rural populations depend on forests and tree products for medicinal products. Trees make up a large proportion of medicinal plants in Kenya. Planting medicinal trees will contribute to improving the health of rural populations as it contributes to maintenance of biodiversity in rural landscapes.
Farm forestry to meet wood and fibre needs of rural populations	In many parts of Kenya, natural ecosystems are not able to adequately meet the wood and fibre needs of rural populations and climate change will likely exacerbate this problem. A number of projects have worked on farm forestry and plantation of woodlots. Lessons learned form these projects need to be applied at wider scales to increase rural wood production and reduce pressure on natural ecosystems, particularly for firewood.
Farm forestry to meet commercial wood and fibre needs	There is little experience with using farm forestry approaches for commercial timber production. Out-grower schemes may be worthwhile to consider for bioenergy and small timber production.

5.6 Forest Adaptation to Climate Change

For the actions regarding facilitating ecosystem adaptation to climate change, there are a few actions at present that warrant investment. Monitoring of ecosystem health is an

important action that needs to be undertaken. Kenya needs credible baselines against which to measure change and rapid feedback to responsible agencies of damage that is being caused to forest ecosystems. Rehabilitation needs to be undertaken in the most damaged ecosystems. Finally, planning exercises related to forestry and meeting the countries' wood and fibre needs must factor the likely effects of climate change into projections and plans.

On this last point, measures have been put in place and efforts made to improve the performance of the sector in terms of forest resources conservation and management for the purpose of attaining sustainable production, improvement of ecological functions and overall environmental conservation, including the enhancement of the capacity for carbon storage and sequestration. Notable measures include revision of key policies and legislation relating to environmental management, enactment of law and creation of structures with overall mandate for environmental management, coordination and formulation of environmental policies and their implementation, formulation and implementation of forest resource management plans and creation of good political climate conducive to better management of natural resources. It is also worth noting that all the government development strategic papers recognise the importance of incorporating the management of natural resource and environmental protection into the overall national economic development. As Kenya translates these policies into actions, the expected impacts of climate change on forest resources and rural communities need to be factored into action plans.

Potentials and opportunities do exist inside and outside the country to omprove forest management and the state of Kenys's forest resource. Some of these potentials and opportunities include, the government's willingness to involve the communities and other stakeholders, the communities willingness to be involved in forest conservation and management, improved financial allocations, improved donor confidence, existence of a wealth of professionals within the country, existence of competitive market for forest products, global developments in science and technology, and the emerging democratic systems of the government. Implementation of the measures put in place and exploitation of the existing potentials and opportunities will go along way in addressing the factors that are affecting the forest sector.

The Forest Bill 2003 once enacted will bring wide ranging changes to the forest sector in general and the forest department in particular. The main provisions in the bill include:

- Tightened conditions to any change of forest reserve boundaries and land use.
- Semi-autonomous Kenya Forest Service able to generate revenue and create institutional structures to enhance performance, transparency and accountability.
- Rights of communities to collaborate in forest conservation and management, and wider participation of stakeholders.
- Assume management responsibilities of forests on trustland and private land by forest department if they are not properly managed,
- Regulation for efficiency of extraction, processing and utilisation of forest products.
- Stern penalties for breaches of the forest act.
- Management of plantations on commercial basis.
- Provision for Environmental Impact Assessment and locus standi.

The Water Act 2002. Apart from enhancement of the water resources management and development, the Act has two provisions of special relevance. One is that the Act enables the gazetting of water catchment areas which would mean extra protection and management of sensitive "Water Towers" through dual gazetting. Secondly, the Act allows for commercialization of water supply and this opens up the possibility of inclusion of a conservation levy (user pay scheme).

The National Rainbow Coalition (NARC) Manifesto 2002. The manifesto notes the negative effects of the previous government's actions on the environment that include, excisions of forest land, unplanned issuing of logging licences, lack of support to institutions with roles in the forest sector and lack of clear land policy. As part of its strategy to develop the national environmental conservation and sustainability, the NARC government commits itself among others to;

- Work with the communities to develop work plans for environmental protection, rehabilitation and conservation.

- Endeavour to educate the communities to understand that they are the immediate losers when forests are destroyed.

- Review the current institutional arrangement of natural resources management and design a new and effectively coordinated institutional structure.

- Design a formal policy based on partnership with communities to ensure sustainable natural resources and protection of areas with critical biodiversity which require preservation.

- Support research on natural resources with an aim of developing appropriate technologies and management systems.

Forest Department has taken a cue from the NARC manifesto and taken actions that include: incorporation of the NARC aspirations in the draft Forest Policy 2002, initiated development of management plans with full involvement of communities, creation of awareness to the communities in protection and rehabilitation of forests and being at the forefront in the ongoing institutional reforms.

The Poverty Reduction Strategy Paper - Government Action Plan 2002. As stated earlier in this paper, poverty is among the driving forces for land and environmental degradation which must be addressed as a root cause. To this effect the government has come up with the Poverty Reduction Strategy Paper which addresses issues related to environment conservation, including promotion of partnerships with the communities and other development partners in the delivery of agricultural extension services, stakeholders participation for sustainable forest conservation and management, increased use of improved stoves and on farm tree planting, and promotion of alternative energy sources including biomass. Emphasis is also put on the need to promote alternative income generating activities that are compatible with sustainable management of natural resources and appropriate land use to be supported by a land use policy which is to be formulated soon.

5.7 Linking Adaptation to Climate Change with Mitigation through the CDM

In the forestry sector there are a number of activities that can also contribute to removing greenhouse gases from the atmosphere. The Clean Development Mechanism of the Kyoto Protocol allows for the so called Annex I countries to finance afforestation and reforestation activities in developing countries and count the carbon sequestered towards their national commitments for greenhouse gas reduction.

Kenya should explore opportunities within the forestry sector to take advantage of this opportunity and secure additional funding for adaptation measures for rural communities.

The Kyoto Protocol allows for activities for the mitigation of climate change by reducing the load of greenhouse gases in the atmosphere through enhancing "sinks". "Sinks" refers to activities that convert atmospheric CO_2 into biomass for long-term storage in the biosphere. The key requirements are that the land that is being planted does not meet the definition of forest and that it was not covered by forest vegetation in 1990, the baseline year for the Kyoto Protocol. The advantage to Kenya of participating in these activities is that additional funds can be made available through these mechanisms to facilitate sustainable development.

5.8. Institutional Changes

Forest Department is the government institution with the mandate to manage forests within the gazetted forest reserves. The Forest Department also plays an advisory role on forests outside forest reserves. The Forest Bill 2003 provides legal authority to Forest Department to take intervention measures on forests in private farms and trust land. The Bill also provides for decentralization of powers to regions (conservancies) with the formation of Forest Management Communities that will include members from the public and local communities. These efforts offer possibilities for better rural participation in forestry activities. To the extent that these activities can be harnessed to promote rural development and poverty reduction, they will also contribute to making farmers more resilient to climate variability and climate change.

The concept of participatory forest management (PFM) is taking root in the country and Forest Department has taken broad steps towards this end that include, preparation of participatory, and collaborative Forest Management guidelines, initiating of piloting on community participation in a number of forest areas (e.g. Arabuko Sokoke, Rumuruti, Mukogondo, Ngare Ndare etc), drawing up of memoranda of understanding with government institutions, NGOs and CBOs and identification of more areas for piloting activities. Already some community based forestry programmes have been undertaken on collaborative bases between Forest Department, UNDP, GEF and other organizations, particularly around the Mt. Kenya forest ecosystem.

5.9. Upcoming Farm/Community Forestry and Urban Forestry

In the farms both in the high and low potential areas, tree planting as a means of earning income, providing for domestic use and amenities is increasing, and this provides an opportunity to increase tree cover in the country. A lot of research on identification of suitable species and improvement of genetic base has been carried out by KEFRI and some NGOs are promoting exploitation and marketing of non-wood forest products.

In the high potential areas tree planting is being encouraged by the increasing timber prices and the understanding of the valued of timber by the farmers. Apart from the cash gains to the farmers, the tree planting has other benefits such as improvement of agricultural land, prevention of land degradation through soil erosion control, provision of fodder for livestock, provision of alternative source of wood products and increased use of biomass for energy. In addition to all these benefits there will be increased carbon storage and sink and reduction of carbon release to the atmosphere.

The tree planting options available in the high potential areas due to varying farm sizes include agroforestry, tree crop plantations, woodlots and scattered trees on farmlands. These options can potentially assist with poverty alleviation while conserving forests. However, win-win opportunities are few and trade-offs must be made to prevent forests from disappearing (Tomich. et, al, 2001).

In the ASALS, the most important forest products are the non-wood forest products. The indigenous knowledge has helped the communities to sustainably utilise these

resources for subsistence throughout generations. Population growth, poverty and competition for commercial use have resulted in the breakdown of the traditional norms of natural resource utilization. The local communities have become desperate due to the paltry earnings they get from middlemen and as a result the resources are either neglected or destroyed in an effort to find other alternative use of land.

In Kenya the potentials of non-wood forest products have been exploited to a very low degree. However, this area of forest products is receiving a lot of interest due to the recognition of the role they can and do play with regard to uplifting the livelihoods of the communities, sustainable forest management and contribution to the national economic development. If well managed, utilisation of non-wood forest products is environmentally friendly and therefore an important element for sustainable forest management and conservation of biodiversity.

The opportunities available in the ASALS include, abundantly naturally available resources, possibilities of introduction of other tree species suitable to these areas, availability of land, and existing market in the country and abroad. One key opportunity is the traditional knowledge which has over the years has been a driving force to the sustainable utilisation of natural resources. More recently, commercial use of these resources has begun to grow, and production of myrrh and frankincense essential oils in ASALs is providing new opportunities.

Through research in the ASALS, better methods of growing and managing indigenous tree species for timber, fodder, fruits and medicinal products have been developed and are very well being adopted by the communities. Another key area is the introduction of biotechnologically improved tree species which are fast growing with the potential of providing materials for wood energy, charcoal burning and construction within a short rotation of 5-10 years.

On Urban forestry there are new forestry related innovations which could be adopted to mitigate the worsening living conditions in the expanded settlement areas which are often on erosion prone sites or swamps. Most settlers in these areas live in poor conditions and face food insecurity, lack clean drinking water, air pollution and unsanitary disposal of waste and sewage among other difficult conditions. FAO (1999) observes that, since the quality of the urban environment is closely

linked to the economic and social regeneration of cities, tree planting for amenity brings several benefits stimulating outside investment, business development and hence, employment.

5.10. Technological Advances

In Kenya, population pressure is the driving force for the increasing demand of forest products. This coupled with the limited forest resources in the country calls for technological changes in order to bring about a sustainable increase in productivity, enhancement of ecological functions of forest ecosystems and increased forest cover. A number of technological changes need to be made (Table 5-5) to make more efficient use of Kenya's forest resources in ways that contribute to reducing the vulnerability of rural populations.

5.11. Private Sector Involvement

The private sector is getting more involved in programmes related to environmental management and biodiversity conservation. This involvement is coming from various realisations that include, understanding the role of private sector in causing pollution, likely loss of business and other benefits as a result of forest ecosystems destruction and goodwill concern of living in healthy environmental conditions.

Table 5-5: Technologically advances and the means for achieving them in order to make more efficient use of Kenya's forest resources.

Technology objectives	Means of achieving change
Utilisation of more tree species	In Kenya for a long time there has been a restrictive preference to few species to the extent of endangering their existence. A change to this is easy to promote through awareness creation and issuance of policy guidelines.
Improvement in wood processing, including recycling, reducing raw material requirement and the use of small-dimension logs	This can be achieved through licensing conditions that demand integrated harvesting, optimum recovery and utilisation of waste and by-products and, relaxation of duties and other charges. Locally the Jua Kali Industry with the collaboration of NGOs has developed various types and sizes of energy saving stoves which have received widespread use in homesteads, schools, colleges and other private and government institutions. This development should receive more support from the government.
Improvements in environmental standards, making it necessary to adopt processes and technologies that are less harmful to the environment.	This is very well spelt out in the Environmental Management and Co-ordination Act 1999 (EMCA). What remains is to strengthen the capacities of the structures of the National Environmental Authority in order to enforce the provisions of EMCA and turn policy into action on the ground.

Tree improvement and biotechnology leading to higher productivity, especially in the plantations.	Forest Department has achieved tree improvement through biotechnology on eucalyptus species and efforts are being directed to other species including indigenous species. KEFRI has also achieved progress on tree species for the ASALS and this is being well adopted by communities.
New products and process that increase the potential for non-wood forest products	Traditionally communities especially those in the ASALS have been using non-wood forest products for subsistence and local trade. Such products include; food from plants (fruits, leaves, nuts, timber and roots), medicinal plants for human and livestock, gums and resins for cosmetics, honey and silk. Currently some NGOs and international organisations e.g. I.C.P.E and ICRAF in collaboration with the communities are diversifying the utilization of non-wood forest products and promoting local processing and planting of appropriate tree species and, promoting local and international market.

Though the private sector involvement has not fully taken root, it provides an opportunity which should be explored and promoted. Already some companies that use forest resources as raw materials are contributing to the government efforts in reforestation and others have placed requests to the Forest Department for collaborative agreement in the management of plantations. The large water users are contributing toward the management of water catchments and control of soil erosion in areas likely to cause siltation to reservoirs.

Recently, six leading corporate organisation have pledged to support environmental conservation programmes within Kenya and the East African region. This is a good gesture in that some of the corporate entities are the major

sources of greenhouse gases. With the prevailing good political climate it is expected that others will follow.

5.12. Research and Development

In the forestry sector, technology transfer includes sustainable forest management practices, forest conservation and protected area management systems, silvicultural practices for afforestation and reforestation programs, genetically superior planting material, efficient harvesting, processing, end-use technologies and indigenous knowledge of forest conservation.

Forest management not only affects the carbon pools in the forests, but also the pools outside the forest. When wood is harvested from a forest, the carbon in the wood is transferred from trees to products. In addition, the tree species choice, the rotation length and the type of soil preparation affect the soil carbon. The stock of carbon in biomass energy is burned to replace fossil fuel energy hence reducing emissions to the atmosphere.

The major management issues that must be addressed by forestry research in Kenya today are summarized in table 5-6.

Table 5-6: Key foci for research and priority areas within each foci for improved forest management and forestry in Kenya.

Research Focus	**Priority areas**
Improve plantation establishment and management methods	Establishment of mixed species plantations Improve harvesting techniques Understand the service function of tree plantations in rural landscapes
Social Forestry	Silviculture of trees on farms and in rural landscapes Develop management systems and recommendations for better integration of forestry into farms (agroforestry) using indigenous species Economic research regarding the possibility of farm forestry to contribute to poverty reduction Tenure research to understand how forest policies affect incentives to plant trees
Species diversification	Silvics an silviculture of indigenous trees Economics of production of non-timber tree products Tree improvement Indigenous fruit trees
Indigenous forest management	Natural forest regeneration Rehabilitation of degraded forests Ecological service function of forests in the landscape
Special focus on ASALs	Silvics and silviculture Fodder banks: what species where and for which animals Non-timber forest products Sustainable charcoal production
Bioenergy plantations	Biomass fermentation Sustainable charcoal production

5.13. Finance and Credit

National investment needs to be combined with bilateral and multilateral funding agencies to enhance investment in the forestry sector. Climate change mitigation projects and carbon finance may be one opportunity where technology is an integral component of adaptation. The role of private sector funding of projects also needs to be promoted under new initiatives, including the emerging mechanisms such as the CDM. The role of GEF could be crucial assuming that it will reorient its operational programmes to include forestry sector carbon abatement projects.

It is long overdue that Kenya establishes a system that will allow willing farmers to easily get into commercial tree production with support from financial institutions. After all, tree farming is not a bigger risk than livestock or agricultural crops. With known market targets and expected economic returns, financial institutions should be able to offer initial financial support for private forest developers.

5.14 Capacity Building for Environmentally Sound Technology Development, Transfer and Assimilation

Developed countries and multilateral agencies, which have a critical role in establishing and operationalising financial and regulatory mechanisms, monitoring, verification and certification arrangements, and capacity building for technology development, diffusion and assimilation, should increase financial and institutional support and training to the Kenya so as to enable the country to develop, evaluate and assimilate climate-friendly forestry technologies and practices. It is to be noted that technology flow between tropical countries (south-south) is very important due to similarities in ecological and socio-economic conditions and should be enhanced.

There is also need for assistance to prepare guidelines and set up institutional mechanisms to process, evaluate, sanction and monitor forestry-sector mitigation and adaptation projects.

Forestry mitigation and adaptation projects can contribute other environmental benefits such as biodiversity conservation, watershed protection, socio-economic benefits to urban and rural populations through access to forest products and creation of jobs. These projects ultimately

promote sustainable development and amelioration of the land degradation and contribute to the fight against desertification. Forest conservation, reforestation and sustainable forest management practices will provide global benefits (reducing atmospheric CO_2, biodiversity, etc.) and will provide local benefits to forest dwellers and rural communities by providing forest products and better livelihood options.

5.15. Conclusion

Forest and forestry have a twofold place in the considerations of adaptation to climate change. Forestry needs to be integrated into sustainable development initiatives to reduce the vulnerability of rural populations to climate change and climate variability. Forests and forestry enterprises also need adapt to the changing climatic conditions. Future increased climate variability and climate change will add more stresses to the forestry sector as a whole.

To be successful, adaptation planning cannot be undertaken as a separate exercise from other planning processes in Kenya. "Mainstreaming" climate change planning into other planning processes is the key to successful adaptation and limiting the negative effects of climate change. For example, the anticipated effects of climate change need to be factored into poverty reduction strategies and rural development strategies.

In this chapter, we have outlined a number of opportunities to reduce the vulnerability of smallholder farmers through better use of forestry opportunities. Many of the recommendations are not specific to climate change and make good sense from a sustainable development point of view. Those that can be accomplished at low cost, but that have high impacts represent the highest priorities for short-term action.

Successful rural development and successful adaptation to climate change need to be implemented through an integrated ecosystems approach to agriculture and natural resource management. Kenya needs to look for opportunities to create synergies between adaptation to climate change and mitigation the possibilities of carbon sequestration projects. Carbon finance may be useful in promoting adaptation to climate change. Environmental services projects such as the Clean Development Mechanism offer

opportunities to gain experience with these integrated types of projects.

CHAPTER SIX

6. INDUSTRIAL SECTOR

6.1. Introduction

The transformation occurring in trade and industrial production needs to be analyzed as part of a systematic process. Outsourcing, delocalization, improving value addition and specializing in specific segments of the production at the global level has led to the blurring of boundaries between countries, regions and sectors. The shift from assembly and partial production to full industrial solutions structured all over the world is becoming a masterpiece of the global management process.

Industries are emitters of gaseous pollutants that include Greenhouse Gases (GHGs). Under the UNFCCC pressure is mounting for them to engage in a range of mitigation strategies, including engaging in trading schemes and to invest in low-carbon technologies.

Kenya's industrial sector is one of the largest in Sub Saharan Africa. Manufacturing accounts for 13% of the Gross Domestic Product (GDP), a share that has remained constant since 1998. The sector accounts for over 27 percent of Kenya's total export earnings (2001). By the end of 2000, the sector had nearly 700 medium sized and large-scale enterprises, and 1.3 million micro and small enterprises and employs about 300,000 people in the formal sector and 3.7 million in the informal sector. The sector registered a positive growth of 1.2 per cent in 2002 due to several factors. These include reduction of import duty on most raw materials and industrial intermediates, availability of energy and water, expanded market due to the African Growth Opportunity Act (AGOA), Common Market for Eastern and Southern Africa (COMESA) and the East African Community (EAC) trade arrangements. Despite these gains, the sector still performs at less than their optimal capacities due to high costs of energy and poor infrastructure; and increased dynamism of the customer needs and demands.

The cumulative and collective impact of over 1.3 million Micro and Small Scale Enterprises (MSEs) on the environment may even surpass that of large industrial establishments to a noticeable extent. Large industrial establishments are

subjected by law to Environmental Impact Assessments (EIAs) and annual Environmental Audits (EAs).

At present, there is no systematic monitoring of different effluents and emissions resulting from various industries. Some industries have installed plants to partially treat industrial wastewater before discharging their effluents into surface water bodies and sewerage systems while others have adopted and installed technologies which are environmentally friendly and hence significantly reduce their effluent discharges and emissions to the environment.

The National Environment Management Authority (NEMA) is in the process of developing effluent and emissions discharge standards into sewerage systems and natural watercourses.

Kenya's GHG emissions are insignificant especially when looked at globally. The Initial National Communication indicated that Kenya is a net GHG sink. While the country is not a significant emitter of GHGs it is extremely vulnerable to the effects of Climate Change. It is envisaged focus will largely be adaptive measures, but it is also recognized that mitigation measures must be part of the country's path to suitable development. Therefore, Kenya's industrial sector needs to be engaged in these mitigation strategies for combating climate change.

Kenyan industry remains relatively conservative in its approach to the new climate change mitigating technologies. The issues of technologies and climate change may be readily discussed among the government, academia, and the NGO world but private sector has yet to join the debate. Whenever climate change capacity building issues and climate change mitigating options are discussed quite often the private sector does not participate.

A number of industries have however, made significant and cost-effective improvements to their existing production processes in Kenya. Furnace and combustion technology, are widely used in industrial combustion owing to the increased use of wood fuel and fuel oil in the industrial sector. Use of furnace and combustion technology requires utilization of either wood fuel or fuel oil leading to emissions of GHGs in the atmosphere.

The current patterns of industrial output in Kenya are associated with both the use of natural resources as well as the largely unmonitored release of emissions into the environment. The increasing pressures of globalization and

liberalization require that Kenyan industrial establishments, particularly Micro and Small Scale Enterprises (MSEs) continuously improve their competitiveness and environmental performance. Successful adoption of Cleaner Production (CP) strategies provides a part of the solution to both these problems. CP helps MSEs and large industries in meeting their environmental challenges by reducing the generation of pollution at source and quite often with enhanced profitability. The other benefits of CP include better working environments, improvements in product quality, ease compliance with environmental regulations, enhanced company image and creation of new market and employment opportunities.

6.2. Status Inventory of Technology in the Industrial Sector

Kenya's industrial technology acquisition after independence (1960's) was based on the import substitution policy. As per this policy, industrial investments were geared towards local manufacture of the products which were then imported. The policy also advocated the protection of such industries which were manufacturing locally against imports of similar products under the then Foreign Exchange Act.

This however impacted negatively on transfer of environmentally sound technology in the sense that investors from the various parts of the world took advantage of the scenario and off-load and sometimes obsolete technology into Kenya. Some of these old technologies are still in the country.

Later in the 1970's, the industrial policy changed and more focus was put on an export oriented industrial sector. This was not to be easily achieved because it meant that only entrepreneurs with more modern technologies capable of producing high quality products could compete effectively in the Global market could support this policy. Otherwise, the older projects with old technologies were required to acquire to more modern technologies.

The Kenyan industries happened to have been enjoying Government Protection as well as the larger East African region market. They thus relaxed in changing their technologies.

In the 1980's Kenyan industries started to lose their market share in the East African region due to imports of

higher quality and cheaper goods from the new industrialized countries particularly from the Far East.

At the same time, European and American markets started imposing restriction of imports into their regions by using tariff and non-tariff barriers including technical barriers based on meeting certain environmental requirements and standards.

In 1992, the Kenyan economy was liberalized and the Kenyan market became open to products from all over the world. This led to a negative impact on industrial sector. Many industries closed down. A few are still managing to survive but with difficulties even after changing to modern technologies and meeting the Global technical requirements.

6.3. Some Barriers to GHG Mitigation Actions in the Industrial Sector

The barriers to rapid rate of technology acquisition in industry can be classified as technological, institutional, information, financial and market barriers.

Apart from these barriers, absence of an explicit policy on technology development creates obstacles for all stakeholders.

i) Limited Exposure to Contemporary Tools of Environmental Management including Market information on Technology Development and Transfer: Most Kenyan industrial entrepreneurs have inadequate exposure to relevant tools of environmental management such as Waste Minimization, Corporate Environmental Reporting, Green Supply Chain Management, Environmental Cost Accounting, Life Cycle Assessment and Social Accountability Standard (SA 8000). There is still more awareness creation needed on incorporation of the 3R Strategy (Reduce, Reuse and Recycle) in industry entire waste management mechanisms. Plastic Packaging has increasingly come under focus as an environmental hazard in Kenya, and there is need for the Expanded Producer Responsibility Policy as a counter measure to this problem.

ii) Technological barriers including Lack of well developed Management Performance Indicators and Environmental Performance Indicators at company level that are quite essential for benchmarking or comparing performances with other leading companies: Companies need to have adequately trained workers not only in management but specialized training to ensure proper operation of

technologies transferred and also provide after-sales services. Companies need to know how much energy, water, wastes etc are generated per unit output and benchmark these with some of the leading companies. This will aid efficiency and continuous improvement and compliance with Environmental Regulations and requirements. There is need to engender a culture that appreciates meteorology and good record keeping in production.

iii) Enforcement and Compliance with Environmental and Labour Laws: The Directorate of Occupational Health and Safety should strictly enforce the Factories and Other Places of Work Act (Cap 514 of the Laws of Kenya). This Act however, requires urgent revision. There is need for preventive approach to occupational health and safety problems.

iv) There is need for an institution to assist the technology recipients in making appropriate technology selections based on Local Conditions. The activity of this institution would cover: -

- Technology testing, demonstration and certification.
- Managing a database networked with international sources on technology information.
- Offering advisory services including management, information on financial and market services.
- Technology upgrading of well-proven technologies.
- Technical and financial support.

Barriers to Investments in Technology for Climate Change Mitigation

Policies and National Strategies

i. High import duties on industrial equipment and material.
ii. Bureaucratic procedure in authorizing investments.
iii. Political situation/Poor governance.
iv. High interest rates on borrowed money.
v. Subsidies that reduce viability of investments in the energy sector.
vi. Inadequate funds for Research and Development in clean energy technologies from both the government and donor.

Financial

i. Poor access to capital funds for investments in technology improvements.

ii. High interest rates on borrowed money.
iii. High bank transaction cost.

Information and Awareness

i. Poor participation and representation Industry in Energy and Environmental matters.
ii. Little knowledge on the new Environment Act and its implications to industry.
iii. Weak information exchange mechanisms amongst stakeholders.

Institution/Capacity

i. Weak implementation institutions

6.4. Industry and Technologies to mitigate Climate Change

Industry remains relatively conservative in its approach to the new energy saving technologies. A number of companies have however, made significant and cost-effective improvements to existing processes or plant in Kenya. The analysis focuses on furnace and combustion technology.

6.4.1 Technology Review

All the major recent advances in furnace technology fall into one of the four categories:-

- Burner and combustion technology
- Insulation and refractories
- Control systems
- Electric heating technologies

Recuperators and regenerators have been the two major contributors to improved energy efficiency in the field of burners and combustion technology. A recuperator is basically a heat exchanger that extracts heat from the furnace waste gases to pre-heat the incoming combustion air. They will usually only pre-heat the air to a maximum of 550-600^0 C.

Regenerative burners are operated in pairs and work on the principle of short-term heat storage using a porous ceramic bed. The regenerator is very efficient and will recover 85% of the heat from the furnace waste gases. As a result, the incoming combustion air can be pre-heated to very high temperatures, perhaps only 150^0 C. less than the furnace operating temperature. Compared with cold-air burners, regenerative burners can be expected to achieve energy savings in excess of 50%.

If a furnace is to operate at optimum thermal efficiency, then structural heat losses must be minimised. Heat is lost to the furnace in two ways:

1. Heat is absorbed by the structure as the furnace attains its operating temperature
2. Heat is lost by conduction through the furnace walls and roof.

Although electricity is a more expensive fuel than natural gas or oil, it is the favoured energy source. Induction heating is not so efficient but has other technical advantages.

6.4.2 Environmental Issues

Emissions of nitrogen oxides (NO_x) are closely related to combustion temperatures, while sulphur oxides (SO_x) tend to derive from impurities in fuel or stock. There is occasionally some degree of conflict between technologies designed to reduce emissions and those focussing on energy efficiency.

Though these issues may be readily discussed among the government, academia, and the NGO world they remain a mystery to the private sector. Whenever capacity building issues are discussed quite often the private sector is forgotten. It has therefore been difficult to inform the private sector the need for the private sector to come on board with respect to climate change mitigation options. The private sector rarely comes on board when the questions of technologies to mitigate climate change are discussed.

Some of the technologies identified to help mitigate climate change. The following technologies have been identified as suitable for Kenya:

- Change from wet to dry process in cement production
- Fuel Switch
- Afforestation
- Co-generation
- Recycling
- Use of Carbon Dioxide from natural sources instead of manufactured Carbon Dioxide.
- Energy Efficiency Programmes

6.4.3 Cement Production and the Dry Technology

The two major cement producing companies i.e. Bamburi and the East African Portland Cement, have actually changed from wet to dry cement production technology in the years

between 1998 and 2000. A clear policy to force all cement and related industry producing companies to change from wet to dry technology is missing. The dry technology uses less energy for the same amount of cement production.

6.4.4 Fuel Switch

A number of industries could easily change from using fuel oil to wood fuel for their steam requirements. This would reduce the importation of crude fuel. Though industry accounts for only 25 per cent of oil products use any saving in oil usage will go along way in Kenya's expenditure on oil. Oil accounts for 25 per cent of foreign currency expenditure.

James Finley group have changed one of their factories to use the Combined Heat and Power (CH+P) technology, sometimes referred to as co-generation. This factory uses wood to produce steam for electricity generation and for process. It is a shame that none of the small-scale tea factories have so far improved in their energy efficiency. Seven small-scale factories are currently being considered for funding either under the CDCF or directly by IFC. It is hoped that these factories may consider installing Mini-Hydros or CH+P or both where feasible.

6.4.5 Potential for Co-generation

A number of Kenyan industries could actually use the co-generation technology. As mentioned earlier, a number of tea factories could use the technology to reduce their reliance on the national grid for electricity supply. Many of these tea factories currently have installed diesel generators to supplement the grid network. This increases the cost of processing of Kenyan Tea and also increases Carbon Dioxide emission. Through a study done under the GEF-KAM Industrial Energy Efficiency Project done early this year, it is estimated that Kenya would save emission of 240,000 tonnes of Carbon Dioxide emitted annually by simply applying the co-generation technology in the tea sub-sector.

Kenya has not fully exploited the co-generation capacity that exists in the sugar factories. Though Kenyan sugar industries can produce up to 56 MW the majority of the sugar factories actually import electricity from the national grid. Currently, it is only Mumias Sugar Company that supplies 2MW to the national grid. Co-generation would reduce the use of thermal power stations in western Kenya and make sugar production cheaper in the local and international market.

6.4.7 Afforestation

In many government circles it is assumed that only the public institutions and some private individuals do Afforestation. The private sector has demonstrated that it could also help in Afforestation. The case of Kakuzi and the East African Tanning Extract and the large-scale tea estates demonstrate this.

6.4.8 Recycling

Though Kenya leads many African countries in recycling there is plenty of room for developing this technology further. If re-cycling in plastics were emphasized there would be less plastic waste seen all over the country. Recycling saves energy and hence reduction in greenhouse emissions.

6.4.9 Use of natural Carbon Dioxide

A number of industries still use imported carbon dioxide. Kenya is endowed with abundant supply of natural Carbon Dioxide. All it requires is filtration to the required cleanliness. A clear government policy is missing in this direction.

6.4.10 Energy Efficiency Programmes

The draft energy policy emphasizes among other issues energy efficiency in industry. The GEF-KAM Energy Efficiency Project started in the year 2000. It covers among other issues awareness in energy efficiency for the medium to large-scale industries. A similar project is required to cover the smaller industries and the Jua Kali sector.

6.5 The GEF-KAM Industrial Energy Efficiency Project

Introduction

This is a project of the Government of Kenya with budget support provided by UNDP and the Global Environment Facility (GEF). The United Nations Office for Project Services (UNOPS) is the executing agency while the Government Cooperating Agency is the Ministry of Trade and Industry (MTI) through the Kenya Association of Manufacturers (KAM).

The objective of this project will be a reduction of Green House Gases (GHG) emissions resulting from increased energy efficiency within Kenya's small and medium scale enterprises.

The direct beneficiaries of this project are the manufacturing and service industries in Kenya. This contributes to industrial development consistent with the national strategy toward Industrial Transformation to the Year 2020 being implemented by the Ministry of Trade and Industry. The project is also strengthening the capacity of KAM to undertake further initiatives on behalf of its members on energy and related issues. The various capacity building and industrial awareness activities also directly benefit the sub-sector associations (e.g. tea, hotels, sugar, textiles, and others), which are increasing their capability to develop energy efficiency and production improvement programs targeted at their particular members

6.5.1 Background

Kenya's energy scenario is dominated by a high degree of dependence on imported petroleum products. Combustion of petroleum products constitutes the predominant energy source in Kenyan small and medium scale enterprises (SME), accounting for 780,000 tonnes in 1996 and projected to double by the year 2020. Electricity is the second most important source of commercial energy, with installed capacity of 1400 MW coupled with rising demand. Development plans for the next 15 years indicate that additional capacity of 1300 MW will be required.

In spite of increase in energy cost due to its production, use of energy has not been very efficient among SMEs. A survey of various projects in SMEs, estimates that wastage of energy ranges between 10% and 30% of primary energy input. In the past, investment in energy efficiency has been impeded by the historically low power tariffs and price control on petroleum products. This situation is being ameliorated through the new tariff policy, power sub-sector reorganization and the newly liberalized petroleum market.

Other projects have been undertaken in Kenya during the past 15 years aimed at reducing energy use and reliance on oil imports. These include the World Bank project of the 1980s, the Ministry of Energy, industrial energy conservation programme of 1987 with support from Canada and a UNIDO supported energy conservation programme, executed through the Kenya Association of Manufacturers (KAM). On the supply side, Kenya Power & Lighting Company (KPLC) has recently carried out a loss reduction study to identify

cost effective means to reduce distribution losses in the major load centers.

Even after the above initiatives, SMEs have not adopted energy efficiency and conservation measures on a wide scale. The larger enterprises have implemented components of energy efficiency programs but for the majority of SME, reducing energy cost at end-use has not traditionally been a principal concern. Among low energy users, often a lack of information, motivation and know how, financial restrictions as well as market imperfections, rather than technology deficits, result in poor use of energy. These untapped potentials present win-win opportunities for SMEs in lower energy costs, and for Energy Service Companies (ESCOs) in new business.

The following constraints or barriers to energy efficiency are being addressed in the GEF-KAM Energy Project

i) Lack of experience in identifying energy efficiency options;
ii) Lack of information regarding the economic viability of energy efficiency measures;
iii) Lack of ability to develop bankable projects;
iv) Lack of ability to secure financing for profitable projects; and
v) Inadequate institutional capacity to mainstream energy efficiency within the SME and financial communities.

6.5.2 Project achievements

The project has made good progress and has succeeded in raising awareness and capacity in industry to implement energy efficiency projects. It has also impacted on several climate change indicators.

a) Awareness raising:

Awareness seminars have been held in all major industrial centers reaching over 470 personnel from public and private sector. The project has developed and disseminated to local industries and hotels relevant energy efficiency promotional and awareness materials. The industry has been sensitized on the energy efficiency benefits. The increased awareness has increased the demand for energy efficiency services.

b) Training

The project has carried out numerous training activities throughout the country. Total of 30 training courses have been offered which has seen over 1000 personnel from industry, finance institutions, government and national

consultants trained in specialized energy management courses. The topics include:

The project facilitated the first certification programme in Kenya in collaboration with the Association of Energy Engineers (AEE) of USA. The Certified Energy Manager Programme in 2004 had 10 participants with 8 of them qualifying for certification.

c) Energy Audits

The project has involved national and international energy consultants in conducting over 20 energy audits for industries in major industrial towns. Substantial savings have been achieved by industries that have implemented the identified measures. More than 30 industries have already requested for energy audits.

d) Financial barriers

The project has carried out activities that address financial barriers to energy efficiency. These include:

- Financial engineering training to equip technical personnel with bankable project preparation skills
- Research on what facilities exist in financial institutions that make energy efficiency financing easier
- Preparation for an energy efficiency investor's guide is well under way.

e) Demonstration projects

The project is working closely with six companies to develop demonstration projects and case studies in energy efficiency. Detailed audits have already been carried out and some projects identified in the industries. Some of the projects have been implemented while others are under way. The 1st phase on demonstration Projects involving three industries was completed in December 2003. Energy savings from the implemented projects range from 9.7% - 10.6%. Spin Knit Ltd achieved overall savings of 10.6%, Chandaria Industries - 9.7%, and General Motors EA Ltd - 10.4% savings. Total average energy savings of 10% were achieved in the first six months.

These demonstration projects have been documented and case studies developed. They are being disseminated through brochures and on the newly launched KAM website to create awareness and stimulate interest in Energy Efficiency projects.

f) Industrial Energy Efficiency Network

The project has established the Kenya Industrial Energy Efficiency Network (IEEN) to increase Energy Efficiency awareness and stakeholders participation in Kenya. IEEN's major objective is to stimulate industries and hotels in Kenya to initiate energy efficiency and conservation.

Membership to the IEEN is free to all industries who have shown readiness and willingness to share information and experiences in the area of energy management. The Network comprises of 8 sectors namely; textile, bakery, dairy, grain milling, edible oil, leather, hotels and leather.

Studies have been conducted for the following sectors: Edible Oils, Grain Milling, Tea and Hotel. More than 90 industries have become members of the IEEN. Members continue to receive energy management services from the IEEN. Specialized training in Energy Management has been conducted for the Dairy and Hotel sectors

g) Economic and non-economic benefits:

A study carried out in 2003 to assess the project impact revealed that the project has a significant impact in raising awareness on the economic benefits of implementing energy efficiency programs.

Total annual savings of approximately USD 1 million were realized by ten of the companies surveyed, with an estimated capital cost of USD 1.1 million, yielding a simple investment payback period of 1.1 years. 37 of the industries surveyed in the study have reduced CO_2 emissions by an estimated 8.1 thousand tons. The amount of savings and CO_2 avoided is expected to rise over the project period involving over 500 local industries.

The project is developing an energy efficiency database for reference by industry and energy consultants.

h) Energy Award Scheme

In 2004, the project initiated the Energy Management Award in Kenya. This is an annual award designed to recognize enterprises that have achieved outstanding energy savings, cost reductions and environmental conservation through the implementation of sustainable energy management programmes. Application is open to all industries in Kenya's manufacturing and hotel sectors.

i) Collaboration

The project has held discussions and is collaborating with several institutions such as Kenya Industrial Research and Development Institute (KIRDI) on development of Energy Efficiency Standards in conjunction with Kenya Bureau of Standards.

ii) Sustainability

PMU has proposed that they become involved in establishing a model ESCO as part of the privatization strategy of the Project. GEF will be approached to provide possible guarantee fund for startup operations. Experts will be engaged to draft contracts and working documents for Kenyan ESCOs.

iii) Lessons

a. The partnership between Government, UN, GEF and Private sector in the Project has resulted in great synergy to the benefit of Kenyan industry. Lower production costs for industry will increase profits and allow the expansion of existing industries, thereby alleviating the acute unemployment problem - consistent with government policy.

b. Public initiated programmes - with social and/or environmental objectives – can attract private sector participation if they are linked to economic and business motives of private sector. Increased access to information and capacity building should be included to ensure successful introduction and adoption.

c. Energy efficiency demonstration projects are powerful tools for increasing adoption and replication.

d. Establishment of sound institutional framework and the participation of government, financial institutions and top management in industry are fundamental to the success of energy efficiency and energy conservation in Kenya.

e. There is need for introduction of technologies that mitigate against CO_2 emissions.

f. It is essential to initiate similar projects for other sectors of economies e.g. public institutions, transport and the informal sectors which also contribute to CO_2 emissions.

6.6 GHG Mitigation Actions in the Industrial Wastes Sector

The universal goal of the waste management is clearly spelt out under the Basel Convention as, their continuing minimization, where feasible with their ultimate elimination of total releases. The practical measures to achieve realistic and meaningful levels of release reduction or source elimination would promote environmentally sould management or in the case of the Stockholm Convention promote Best Available Techniques (BAT) and Best Environmental Practices (BEPs) to reduce the level of persistent organic pollutants (POPs) such as dioxins and furans.

The Stockholm Convention is specific on assessment of technologies. For Unintentional releases of POPs (UPOPs) the goal is ESM for Stockpiles, wastes and products and articles upon becoming wastes that consist of, or contaminated by POPs. The definition of BEPs and BATs are being redefined taking into consideration various technologies of treatment and disposal of wastes.

The introduction of ESM and technologies will take into consideration the level of technology in various countries such as:

- Open burning of wastes including landfill sites
- Residential combustion practices as a way off reducing the volumes;
- Review of production processes in industry;
- Waste incineration guidelines;
- Agricultural re-use of wastes;
- Land filling practices.

Land filling is a source of greenhouse gases such as methane while burning is a source of nitrous oxides and carbon oxide. To this end the activities of the Framework convention and Climate Change can be synergistic and complementary. Further, under annex C of the Stockholm Convention is on incorporation of Best Available Technologies (BATs) and Best Environmental Practices (BEPs) which are akin to the clean development mechanisms (CDM)

The Environmental Management and Coordination Act (EMCA, 1999) is a legislative framework for the management of the

Kenyan environment. The Act contains several provisions relevant to waste management in Kenya as outlined below: -

- Duty of the owners or operators of sewerage systems and industrial undertakings likely to discharge effluents or other pollutants or are discharging effluents or other pollutants into the environment to submit on demand, to the National Environment Management Authority (NEMA), accurate information about the quantity and quality of such effluents or pollutants.
- Duty of owners or operators of a trade or industrial undertaking to discharge any effluents or other pollutants originating from the trade or industrial undertaking into sewerage systems.
- Duty of a proponent or owner of an industrial undertaking to install an appropriate plant for the treatment of effluents before being discharge into the environment
- Duty to obtain a pollution licence in respect of emissions form establishments,
- NEMA is empowered to prescribe standards for wastes, their classification and analysis, and formulate and advise on standards of disposal.
- NEMA is empowered to issue regulations for the handling, storage, transportation, segregation and destruction of any wastes.
- Duty to obtain a licence before transporting wastes, operating a waste disposals site or plant or generating hazardous wastes.
- Prohibition of the importation of hazardous wastes into the country.

6.7 Policy Frameworks

Generally, the policies should aim at increasing the flow of climate-friendly technologies by removing the barriers mentioned under Section 6.4. These policies should aim at also fostering the overall development and transfer of technologies.

There are several institutions in the Country that can take part in the various stages of the technology transfer process. These include: -

- Kenya National Cleaner Production Centre, located at the Kenya Industrial Research and Development Institute, KIRDI.
- Kenya Productivity Centre located at Kenya Industrial Research and Development Institute, KIRDI.

- GEF – KAM Industrial Energy Efficiency Project located at the Kenya Association of Manufacturers premises in Westlands.
- The National Environment Management Authority (NEMA) has been operationalised the various committees to oversee the implementation of some of the above issues have been formed e.g. the standard Enforcement and Review Committee (SERC), Public Complaints Committee (PCC), National Climate Change Activities coordinating Committee and the Clearing House Mechanism of the CDM, etc.
- The National WTO Committee with representation from the various stakeholders is operational.

These institutions as has been shown, are responsible for policy development and implementation including that of coordination and monitoring, these are private sector institutions involved in the manufacturing and dissemination of technologies and Research and Development institutions involved in innovation and product modification. However, two major activities are not covered. There is need to have institution(s) to deal with technology assessment and incubation.

The development policy of the Government towards the Micro and Small Scale Enterprise Sector is articulated in a number of Sessional Papers and Development Plans such as:

The development policy of the Government towards the micro and Small Sector Enterprise Sector is articulated in a number of Sessional Papers and Development Plans such as: -

- Sessional Paper No. 10 of 1965.
- Sessional Paper No. 1 of 1994 on Recovery and Sustainable Development to the Year 2010.
- Sessional Paper No. 2 of 1992 on Small Enterprises and Jua Kali Development in Kenya.
- Session Paper No. 2 of 1997 on Industrial Transformation to the Year 2020.
- The Poverty Reduction Strategy Paper (PRSP) for the period 2001-2004.
- Various Development Plans and especially the one for the period 1977-2001.
- Economic Recovery Strategy for Wealth and Employment Creation 2003-2007.

Although a number of these documents contained Environment related policy statements, it was not until the enactment

of the **Environmental Management and Coordination Act** that the 77 statutes addressing issues on environment were Consolidated and harmonized.

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The Environmental Management and Coordination Act (EMCA) legal notice No.8 of 1999 is designed as a framework environment legislation to guide and regulate environmental management. It also provides for the establishment of an appropriate legal and institutional framework for the management of the environment in Kenya. The main focus of this Act is to assume coordination and supervision roles, particularly as regards the National Environment and Management Authority (NEMA) and the attendant committees. The Act aims to provide a framework to manage cross-cutting issues of environmental management and brings into focus new methods of managing all aspects of the environment.

It is now official Government Policy that all new projects have to undergo an initial Environmental Impact Assessment while on going projects have to undertake annual Environmental Audits (EAs). With this law, industrialists and developers are required by law to carry out EIAs and EAs, contain all by-products from their establishments, protect and manage the environment and public health. NEMA as a matter of priority is now developing environmental management tools such as regulations, standards and guidelines that will enable compliance and enforcement.

6.8 Intellectual Property Rights and Climate Change

6.8.1 Introduction

With the increasing techno – economic development in developing countries such as Kenya, the economic value of intellectual property protection also consists of keeping the environment free from pollutants to the extent feasible. Access and protection to environmentally friendly technologies that will not cause climate change are necessary. This is also because inventions have resulted into industrial growth that has been accompanied by the reversal effect of global environmental crisis. The growing technology –base industry has had an important environmental impact being the major consumer of natural

resources and major contributor to the overall pollution load. It generates traditional pollutants such as CO_2, SO_X, and NO_X emissions, hydrocarbons, volatile organic, metals (chromium, cadmium, mercury, lead) pesticides and newly invented pollutants such as chlo-flourocarbon (CFC), halons and dioxins.

6.8.2 Intellectual Property Rights

Intellectual property rights refer to creations of the mind. These could be inventions, literary and artistic works, symbols names or images. They are protected under regimes such as patents (for inventions) copyright for (literary and artistic works), Trademarks (for signs and marks). Intellectual property rights (IPRS) are like other property rights only that they allow the creator or owner of a patent, trademark or copyright to exclude others from using his creation without his authority.

Table 6-1 below shows 1 Property Rights application since 1990.

S. No.	Industrial Property	Applications	Granted	Rejected	Pending
1	Patents	830	210	54	586
2	Trademarks	65,876	48,905	2,471	14,500
3	Ind. Designs	432	367	25	40
4	Utility Models	56	41	-	15
5	Technovations	-	-	-	-
	Total	**68,024**	**49,513**	**2,550**	**15,141**

Source KIPI Registry

6.8.3 Kenya Industrial Property Institute

Kenya Industrial Property Institute is a body corporate under the Ministry of Trade and Industry. It was established in 1990 primarily to administer and promote innovative activities in the country.

Vision: To be a centre of excellence in the protection, training and promotion of Industrial Property Rights for national growth.

Mission: To administer Industrial Property Rights, provide technological information to the public and promote inventiveness and innovativeness for accelerated

technological and sustained industrial and social-economic development of Kenya.

Core functions:

1. To consider applications for and grant industrial property rights (i.e. patents, industrial designs, utility models, technovations, trade mark and service marks).
2. To provide to the public, industrial property information for technological and economic development.
3. To promote inventiveness and innovativeness in Kenya.
4. To Screen technology transfer agreements and licences, and
5. To offer training in Industrial Property Rights to the public.

6.8.4 Patentable Technologies

An invention is a solution to a technical problem. It can be a product of a process in one of the following categories of technology:

1. Human necessities e.g. agriculture, foodstuff, tobacco personal or domestic articles, health and amusement.
2. Performing operations and transport including separating, mixing, shaping and printing.
3. Chemistry and metallurgy, which covers new compounds, atoms, molecules, metals etc.
4. Textiles and paper
5. Fixed constructions such as building earth moving and mining inventions.
6. Mechanical engineering that covers lighting heating weapons, Bio-weapons including engines or pumps and engineering in general.
7. Physics e.g. instruments, nucleonics.
8. Electricity.
9. Biotechnological product and processes.
10. Diagnostic kits or products.

6.8.5 Excluded from Patent Protection

The following are not regarded as inventions and are therefore excluded from patent protection under section 21 (3) of the Act;

a) Discoveries
b) Scientific theories
c) Mathematical methods
d) Schemes rules or methods for doing business performing purely mental acts or playing games.

e) Methods for treatment of the human or animal body by surgery or therapy
f) Diagnostic methods practiced in relation to treatment of human or animal body.
g) Mere presentation of information public health methods or substance treat that disease which the minister has designated as a serious health hazard.

6.8.6 Non- Patentable Inventions

According to Section 26 of the Industrial Property Act, 2001, the following inventions are non-patented

a) Inventions that would qualify for protection under the seed laws of Kenya e.g. new plant varieties that whose innovators/discovers would be granted Plant Breeders Rights (PBRs).
b) Inventions contrary to;

- Public order
- Morality
- Public health and safety
- Principles of humanity
- Environment conversation

6.8.7 The Role of Patents in Cleaner Production Technologies

Patents provide incentives to individuals by offering them recognition for their creativity and material reward for their marketable inventions and investment. These incentives encourage innovations in all fields of the technology including those that are environmentally friendly. They ensure that the quality of human life is continuously improved. Patented inventions have, in fact pervaded every aspect of human life from plastic patents to microprocessor patents. Patent owners are required to fully disclose information on their invention in order to enrich the total body of the technical knowledge in the world.

KIPI has more than 2000 CD Roms that contain well over 12 million patent documents commercial and legal information.

Users of Patent Information at KIPI

1. Industry e.g. R & D intensive industry
2. Research and development institutions such as public research institutes and universities.
3. Government authorities
4. SMES
5. Individual inventors

6. Professional in the field of industrial property e.g. administrators of technical libraries, patent agents, researchers, producers of data banks.
7. Educational institutions and universities.

6.8.8 Screening of Technology Transfer Agreements and Licenses

One of KIPI's mandatory function is to screen technology transfer agreements and licences. However, this function is now absolute given the following liberation of the economy. The function was basically meant for foreign exchange controls. Today, KIPI can only advise on the state-of-the-art in a particular technical field given its enormous storage of patent documentation and information.

Under Section 68 of the Industrial Property Act, the Managing Director would reject a licence contract if it would be harmful to the economic interests of Kenya and especially if the contract is to:-

1. Permit importation of technology that would have been made locally.
2. Require payment of a price, royalty e.t.c. which is disproportionate to the value of the technology to which the contract relates.
3. Require the licensee to acquire any material from the licensor unless otherwise,
4. Prohibit the licensee from acquiring any material from any source.
5. Require the licensee to sell products produced or make appropriate improvements to the technology.
6. Limit the volume of the products produced by the licensee with the help of the technology or restrict the export of the products produced.
7. Oblige the licensee to employ persons designated by the transferor not needed for the efficient transfer of technology unless the contract provides for training of persons to replace them within a reasonable period.
8. Impose restrictions on research or technological development carried out by the licensee to absorb or adapt the technology to suit new products, processes or equipment.
9. Exempt the licensor from any liability consequent upon any defect inherent in the technology.
10. Extend the coverage of the contract to technology not required for the use of the technology.

11. Prevent the licensee from adapting the technology to local conditions or introducing innovations in it.
12. Restrict the licensee from taking measures that will enhance local technological capability and use of local expertise in management and consultancy e.t.c.

6.8.9 Access to Essential Technologies

According to section 72 – 80 of the Act;

1. A compulsory license may be granted by the Tribunal after 4 or 3 years from the date of filing or date of grant if the patented product or process is not working.
2. Compulsory licenses based upon interdependence of patents. The owner of the first patent may be entitled to a cross – license on reasonable terms to use the invention of claimed in the second patent.
3. Compulsory license granted by the government or to a third party authorized by the government to exploit patented invention;
4. Exploitation of patented inventions by the government in the public interest, especially national security, nutrition, health, environmental conservation, for the development of other vital sectors of the national economy.
5. Parallel importation of patented technologies.

6.8.10 IPRs and Technology Transfer

Proponents of a strict IPRs regime have argued that it would encourage innovation and contribute to technology transfer. A strong IPRs regime in a country encourages the inflow of Foreign Direct Investment(FDI), which in turn will bring about technology transfer to the host country. Strong IPRs in developing countries, the TRIPs Agreement can also encourage foreign firms to import technology thus providing employment.

A study of the effects of IPRs on technology transfer on the implementation of the Montreal Protocol on the phase out and access to substitutes for chloroflourocarbons (CFCs), chemicals used in industrial processes as a coolant, which damage the atmospheres ozone layer. Alternative substitutes include Hydroflourocarbons (HFC 134a) which is a greenhouse gas that constributes to global warming with its resultant effect on Climate Change.

6.8.11 Patents and Environmental Conservation

The role of IPRS must be incorporated in environmental conservation to ensure that there is minimum emission of Greenhouse gas that lead to climate change. There is increasing public interest in the subject of IPRs and its relationship with sustainable development, especially the environment and human development. This subject has been the subject of rather intense debate in inter-govern mental organizations, including the World Trade Organization (WTO) – Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement, the Convection on Biological Diversity (CBD), Food and Agriculture organization (FAO), the Montreal (1988) and Kyoto (2000) protocol.

Establishment of TRIPs within the WTO in 1994 strengthens the obligation of countries to comply with minimum standards of IP protection with profound effects on environment conservation. Article 27.2 permits member states to exclude inventions from patentability on the ground of protecting Order public or morality, including to protect human, animal or plant life or health or avoid serious prejudice to the environment. In this respect there is room for rejecting patents for those emissions or compounds such as CFCs and Halons that deplete the ozone layer or that cause greenhouse gas effects. Indeed in Kenya, a patent can be refuted under section 26 (b) on the same grounds. Further Article 31 of the TRIPs Agreement provides for national legislation to grant compulsory licences for a patented technology that could be environment or ozone friendly such as hydrochloroflourocarbons (HCFCs) in place of CFCs in refrigeration, air conditioning, foam product ion, solvents, aerosols, sterilization and other uses.

The other techniques would be left to the international treaties on global corporation in the area or recycle and destruction technologies of CFCs, halons and other Ozone Depleting Substances.

Since the world has taken swift and practical steps to begin slowing down and then repairing damage to the ozone layer, Kenya needs to identify cleaner production technologies that will reduce the production and use of CFCs halons that destroy stratospheric ozone. Such technologies may include: -

1. Development of renewable feed stocks or use of alternative feed stocks [e.g. cellulose, starch etc]

2. Use of innocuous feedstocks and reagents [e.g. the use of solid acids as replacement for traditional corrosive acids]
3. Use of natural processes [e.g. biomimetic synthesis]
4. Use of environmentally benign solvents and reaction media [e.g. use of ionic liquids]
5. Development of novel separation technologies [e.g. use of fluorous biphase system]
6. Development new friendly chemical routes or clean synthesis processes that enhance the atoms utilization to reduce waste production
7. Development of alternative reaction conditions that increase product selectivity and reduce waste emissions [e.g. use of super critical conditions]
8. Application of Biotechnology techniques of Bioremediation for waste water treatment system e.g. culturing of algae storing liquid fuel using sewage treatment water as nutrient and Reuse of spent enzymes.

6.8.12 Case Study on Technology Transfer

The Montreal Protocol on Ozone Depleting Substances is a good study on technology transfer. Technical expertise is being developed by mainly the richer countries that up till now have been the main producers and consumers of CFCs.

Montreal protocol acknowledges that stopping the destruction of the ozone layer is a global problem requiring global solutions. For Kenya to leap-frog the older polluting technologies and move directly to new environmentally sound technologies, a variety of international technology transfer mechanisms will be needed, such as: -

(a) Technical Training
(b) Trade incentives
(c) Joint ventures
(d) Multi and bilateral assistance
(e) Access other funding mechanisms such as:
    i. Increasing overseas development aid
    ii. Charging for CFC use OR
    iii. Contributing a small percentage (0.1%)of GNP.
(f) The Government to impose a transiting fee on CFCs e.g. a fee of 25 US/Kg linked with ozone depletion potential.
(g) Multilateral development institutions such as the World Bank and Africa Development Bank could facilitate the transfer of technology needed.

(h) Global Environment Facility (GEF) should be strengthened to provide more funds.
(i) Multilateral lenders supporting the goals of the protocol could include CFC substitution as a condition for loans/grants. Loans for establishing alternative technologies could be encouraged rather than those projects aimed at reducing CFCs
(j) Protocol signatories could grant special access to their markets for CFC substitutes produced by developing countries while restricting products containing or made with CFCs.
(k) Direct subsides could be provided for CFC free products for example by providing grants for manufacturing the substitutes used in CFC –free.

6.9 **The Kenya National Cleaner Production Center**

Since its inception in July 2000, the Kenya National Cleaner Production Center (KNCPC) that is supported by UNIDO/UNEP/UNDP has been involved in the promotion of the cleaner production program that aims to:

- Increase productivity by ensuring a more efficient use of raw materials, energy and water
- Promote better environmental performance through reduction at source of wastes and emissions
- Reduce the environmental impact of products throughout their life cycle by the design of environmentally friendly but cost-effective products.

The net effect is to give enterprises in developing countries a more competitive edge, thereby facilitating their access to international markets. UNIDO's holistic approach to cleaner production includes its application in sectoral activities, as well as the implementation of multilateral environmental protocols through development and transfer of cleaner production technology and investment promotion. Cleaner Production requires changing of attitudes, exercising responsible environmental management and promoting technology change.

Through its core functions of cleaner production awareness raising through seminars, conferences, workshops; training; setting up of demonstration projects; disseminating information on available cleaner production technologies and policy advice and analysis, the KNCPC has reached out to over 40 companies that are now embracing the cleaner production practice and are cleaner production proud. A lot still needs to be done. One of the cardinal advantages of

cleaner production is its ability to improve the techno-managerial capability of technologies that are already in use. This is achieved through the adoption of waste minimizing techniques of cleaner production such as:

- Input material substitution
- Good house keeping
- Better process control
- Equipment modification
- Technology change
- On-site reuse and recovery
- Production of useful by-products
- Adoption of Energy Efficiency program
- Product modification.

Successful adoption of these techniques will enable firms to cut down on their GHG generation without changing the technology all together. The Kenyan cleaner production program has so far enabled Kenyan enterprises to achieve:

- Cost savings through reduced wastage both of energy and materials
- Improved operating efficiencies of the plants
- Better product quality and consistency
- Recovery of some wasted materials
- Possibility to improve the working environment (health and safety)
- Improvement of the enterprises image
- Better compliance with environmental regulations
- Cost savings on end-of-pipe waste treatment
- Measurement and trending culture that keeps records that are discussed for target setting and continuous improvement.
- Development of management and performance indicators for purposes of benchmarking
- New and improved market opportunities.

CHAPTER SEVEN

7. SOLID WASTE MANAGEMENT AND WASTEWATER TREATMENT

7.1 Introduction

Waste comprises of any material that is regarded to have lost its usefulness and requires disposal. Waste is classified as gaseous, liquid or solid and can be categorized as industrial, municipal, commercial and agricultural. Sound solid waste management is mandatory so as to achieve a clean healthy environment. Poor waste management presents both public health and environmental hazards. The solid waste management cycle involves generation, handling, storage, collection, transport, treatment and final disposal.

Wastes may be from chemical, metal, wood, leather, textile, or chemicals industries. However, repair and maintenance services also produce wastes, which are difficult to treat or dispose, as they are not easily biodegradable. Cost effective technology is needed to do this.

Agro-industries or services generate biodegradable organic wastes. These wastes cause short-term environmental impacts such as pungent smelling gases. The technologies are readily available.

In Kenya like many other developing countries, waste management continues to be a significant problem having adverse environmental impacts to its citizenry. Due to the low awareness levels, hazards associated with waste management have not been recognized or given sufficient attention to the extent that can sufficiently protect human health and the environment. The problem is that Kenya lacks both the experience of dealing with technologies for dealing with waste problems, the funds and the necessary institutional infrastructure for monitoring environmental and health standards.

As the Kenyan population rises, the technologies for collection, treatment of disposal need to be assessed and applied to meet the demands of environmental standards and the ability of a people to meet the costs of their management and improve their quality of life.

Waste is currently disposed off indiscriminately posing a threat to human health and the environment. The past and current practice in the manufacturing sector is to minimize waste by recycling or incorporation of cleaner production technologies among other initiatives. Hydrocarbons like waste oil and solid wastes contaminated with oils are disposed off in landfills. In such industries, point source stack emissions are not monitored for contaminants concentrations and compliance with the air emission guidelines. In a study carried out by NEMA, disposal problems for medical, industrial and municipal wastes are discussed and technologies proposed. This paper also focuses on the need for technologies to meet local and international requirements and performance.

There are various attempts to dispose wastes through burning in incinerators, boilers, metal furnaces, cement kilns and other systems that were not designed for this purpose. Such practices have led to atmospheric pollution and increased hazards to human health as a result of the relatively low combustion temperature of contaminants such as heavy metals and chlorides present in industrial waste. Other disposal means have included deep well injection, land spreading and burial. Whereas these technologies may not be affordable in Kenya, their intermediate alternatives are vital.

The amount of methane emitted to the atmosphere from solid waste disposal depends on the amount of waste that is disposed, its composition, and the nature of the disposal mechanism. Mitigation technologies involve management techniques that can be incorporated at any one, or a combination of these points. Furthermore, collecting and using the methane generated can also reduce greenhouse gases emissions.

7.2 Status of Waste Management

7.2.1. Categories of Waste

The major categories of waste streams are:-

- Municipal and hospital
- Waste oil
- Sewage Sludge
- Industrial waste
- Household waste

Dandora Dump Site in Nairobi handles waste to the tune of 803,000 tonnes a year. There is a continuous accumulation of such waste often disposed through open burning.

Mombasa, Nakuru and Kisumu which are the major towns after Nairobi between them dispose 1,124 million tonnes through open burning. Overall, it is estimated that a total of 5.26 million tons per year of waste are disposed through open burning and methanation in all the urban centres in the country.

Because organic matter can generate methane over 10-30 years or more, methane recovery programmes may be particularly appropriate to address the near and mid-term GHG emissions in parts of the country where large amounts of organic waste have already been or are presently being land filled.

7.2.2 Industrial Waste

The major industries generating waste, posing bulk disposal problems include: -

- Tanneries and textiles
- Sisal and plastic industries
- Transport Industries (petrol stations, garages)
- Ferrous and non ferrous metal industries
- Slaughter-houses and abattoirs

The quantities of such waste volumes are difficult to quantify due to lack of data. However, with the new requirement for such facilities to undergo either an environmental impact assessment or environmental audit, it will be easier to collect and collate data on waste generation.

7.2.3 Medical Waste

The medical waste generation comprise of a waste stream that has not been quantified. As a rule the majority of incinerators in Kenya are in the medical sector. For example 41 of the 77 districts in the country have the De Mont Fort type of incinerators, which are operational. An additional 24 are due to be constructed across the country while a further 8 are planned for construction.

Where incinerators are applied, they operate at an average temperature of 900°C. Many of the hospitals use open burning as a means of reducing volumes for those waste streams to be of significantly low risk e.g. paper, plastics, and clothing, among others. While cement kilns can be used, in Kenya cement kilns do not fire hazardous waste.

7.2.4. Waste Oil

Waste oil usually comprises of lubricants. Kenya generates some 33,000 tonnes of waste oil per year. Less then 10% of waste oil generated is collected. That which is collected is used as timber preservative, dust suppressant or fuel for low-level burners. The environmentally sound management of this waste is recycling. Two facilities namely:- East Africa Marine Environmental company in Mombasa has a capacity to recycle 13,000 tonnes and Optimum Lubricants in Limuru 10,000 tonnes/year.

7.3 Current Waste Disposal Technologies

7.3.1. Municipal and Hazardous Waste, Sewage

The burning and incineration of waste, often accompanied by the recovery of energy and recycling of residues is practiced by some sectors. The environmentally sound design and operation of the waste incinerators requires the use of best environmental practices and best available technique to prevent or minimize the formation and release of gaseous emissions.

The primary benefits of waste incineration are the reduction in volume of the waste and the generation of steam or electricity. Other benefits including the destruction of toxic materials, sterilization of pathogenic wastes, the re-use of some residues and recycling of others.

7.3.2. Waste Co-Burning

Alternative fuels (also known as waste-derived fuels) are materials that are rich in energy such as used tyres, Waste wood, used oil and spent solvents which can be used to replace fossils fuels as a source of thermal energy. Potential contamination of alternatives fuels by undesirable waste materials/substances is an issue associated with this fuel source. Fuel quality management and good combustion conditions in combination with an effective collection device appears to offer the most environmentally sound technologies with low potential of air pollution. For the most effective operation waste materials should be specifically excluded from the process during start up or shut down when combustion conditions are less likely to be both stable and controlled.

7.3.3 Composting

Solid waste composting depends on its composition which can change as a result of increasing material consumption. Active recycling techniques, such as composting, can be used to minimize the unnecessary disposal of organic waste in landfills.

7.3.4 Open Dumpsite

Solid waste disposal in Kenya is often in tips or open dumps where it is openly burnt and is a source of nitrous oxide and carbon dioxide. Aerobic disposal systems such as above tend to generate less methane than landfills, where operating practices generally require that the waste be covered with dirt for odor control and other environmental reasons. However, such tips can become anaerobic and generate methane under certain conditions.

7.3.5 Incineration

Incineration is practiced in a number of premises. This reduces methane emissions, but increases carbon dioxide and other air pollutant emissions, and produces ash, which must be disposed of. Incineration may be more widely applied in the future, although care must be taken to ensure that waste composition and other factors are appropriate for effective combustion, and attention should be given to improving combustion efficiency when possible. Appropriate control of air emissions from a variable composition waste stream is also of concern.

7.3.6 Cogeneration

Cogeneration, in which the heat from an incinerator is used for energy production or direct heating, further reduces GHGs. Cogeneration is practiced in some industries with significant reduction of waste and GHG emissions.

7.3.7 Impacts of Waste Disposal

MSW management contributes to climate change through the various ways of their collection and disposal. The major causes include:

- Their heterogeneous nature at their point of generation/storage.
- Their indiscriminate open dumping that facilitate chemical reactions that produce greenhouse gases.
- The open burning of waste as practiced in the informal settlement
- The crude open dumping at the tipping site

It is noted that generally crude open dumping of waste contributes to climate change.

In the Assessment of technologies, consideration is made on the waste stream and its management. Two cases of medical and industrial wastes are considered. Since most wastes are wrongly categorized as municipal waste, it is important to note the composition of specific waste streams in an effort to understand the technology and practices in waste treatment or disposal. Wastes from health and chemical sectors are selected as examples in tables 7.1 and 7.2.

Apparently 75% of waste is biodegradable. The technologies applied for disposal include burning, land filling and incineration. The practice of open burning is prevalent, while the practice of sorting out waste is not widespread. Ideally waste could be disposed in a sanitary landfill. The presence of plastics in the waste makes open burning as a mode of disposal unsuitable as it is a source of highly toxic pollutants such as dioxins and furans, general air pollutants such as sulphur dioxide or greenhouse gases such as oxides of carbon and nitrogen.

7.4 Waste Water Treatment

There are three basic approaches toward reducing methane emissions from wastewater treatment systems, which is practiced to some extent in Kenya. The wastewater and sludge are stored and treated under aerobic conditions, where methane emissions are eliminated. Other technical options include aerobic primary and secondary treatment, and land treatment. However, it is to be noted that aerobic treatment of wastewater requires energy input for aeration, which may result in offsite increases in greenhouse gas emissions. Alternatively, wastewater can be treated under anaerobic conditions and the generated methane can be captured and used as an energy source. Feasibility of this is the Municipalities across the country are yet to be assessed. Depending on the amount of methane available, it can be used to heat the digestion tanks, as a fuel for other processes, or to generate electricity. The use of methane as an energy source through this process has yet to be explored in Kenya. The country is however, making attempts to reduce industrial waste generation, thereby minimizing the amount of wastewater requiring treatment.

7.5 Assessment of current Technologies

Wastes have the potential to pose significant adverse health impacts to humans and ecosystems over time. Even small amounts of persistent organic pollutants that enter the environment had been known to accumulate to high concentrations in the environment and in organisms and result in adverse effects to human health and the environment.

The scientific evidence of the environmental and public health impacts of incinerators, cement kilns and similar combustion systems have created strong public opposition to burning wastes in the open. While disposal in landfills has the potential to result in contamination of groundwater and transfer pollutants across ecosystems.
Large investments are required to provide adequate waste management services.

Climate-related impacts of waste management choices has not been a routine consideration, however internationally available mitigation technologies can be readily deployed to provide benefits beyond the reduction of GHG emissions, such as reduced landfill space requirements and/or additional energy generation through methane recovery. A range of destruction technologies has been developed around the world, which can overcome the inherent limitations of incineration and other combustion methods. The technologies generally use physical and chemical means of converting wastes to less harmful substances. The choice depends largely on the quantities to be generated the infrastructure available, local regulations and cost effectiveness.

7.6 Mitigation technologies

A variety of technologies and approaches are available to reduce the methane emissions associated with solid waste disposal and wastewater treatment. In the area of solid waste disposal, options include source reduction, methane recovery from disposal sites, and in some cases aerobic treatment of solid waste, through composting or other means. Similarly, methane emissions from wastewater treatment can be reduced through methane recovery or use of aerobic treatment facilities that do not generate methane.

The complete life cycle of waste products needs to be considered. Thus, at first sight, the use of household anaerobic compost systems for organic waste would not appear to be a mitigation technology. Such compost bins generate methane, although most compost bins maintain

aerobic conditions through frequent turning. However, if the compost from these bins is used instead of inorganic fertilizers or is used to fertilize growing plants, which act as a carbon sink, then it can be argued that the technology is a mitigation technology, because it either replaces a source of carbon emission (manufacture of inorganic fertilizer), or enhances a carbon sink. The alternative use of the household organic waste-namely disposal to landfill-would not do this, especially if the landfill lacks a methane recovery system.

7.7 Factors Determining Choice of technologies for Municipal Waste.

Technology transfer in the waste management sector occurs predominantly along government driven pathways with several levels of government participating in its implementation. Because of the lack of separation of various wastes it can be assumed that all waste generated in Kenya is municipal solid waste (MSW). The BAT or BEP is that technology or practice that makes cost management effective. Generally it is important to note that:

- BAT & BEP for municipal Solid Waste (MSW) revolves around issues of policy, regulatory regime, economic and voluntary measures taken by all stakeholders, in conformity or singly to address specific emissions.
- While a common definition of MSW is lacking as it often is a mixture of industrial, agricultural, or domestic and one may develop/adopt technologies that cover the whole spectrum of wastes.
- Data on composition of MSW is also lacking to give clear and uniform BAT & BEP guidance, for what is ESM for a region or what is good for its environmental situation;
- It is misconception to assume all MSW is residential waste as only 30% (approximately) is in this category. The rest is often toxic chemicals, which makes the wastes hazardous to the environment and thus requiring special technologies and practices.
- Solid waste from rural areas is often not quantified however it must be noted that rural people are more responsible at waste management than their counterparts in urban areas;
- There is need for comprehensive product design to interlink all aspects of MSW management to take into consideration other management practices such as

aerobic treatment digestion, gasification that are appropriate and suitable for a region.

7.8 Technology Needs

Key government priorities are establishing appropriate policy/regulatory frameworks, supporting the expansion of private sector participation, and participating in technical assistance and capacity building activities. Increasingly more NGOs/Community Groups are getting involved and incentives are to be provided to catalyse more participation.

The following technologies are necessary for environmentally sustainable management of solid wastes:

- Provision of appropriate recycling technologies to ensure waste reduction
- Provision of commercial composting facilities for urban areas
- Provision of bio-compost units for outlying informal settlements
- Incinerators incorporated with energy recovery units
- Establishment of properly engineered landfills with adequate leachate and gas recovery units

For wastewater management the technologies below can assist in compliance:

- Provision of water saving dispensers in all facilities
- Incorporation of segregation units for the various waste streams
- Expansion of the overloaded aerobic treatment plants currently operating in the facultative mode
- Promotion of cleaner production technologies
- Provision of methane recovery technologies where absent

7.9 Barriers to Technology Assimilation

These include:-

i) Low level of public awareness and participation to technology adoption. Ultimately, the success of any waste management system will depend upon the acceptance and participation of the local population.
ii) Lack of funds for technology implementation. Basic infrastructure to collect and treat solid and liquid waste is inadequate to the limited funds.
iii) Lack of reliable data
iv) Low level of personnel and technical capacity to implement and sustain technological options. Limited

institutional capabilities to collect waste as expected, dispose, operate and maintain treatment facilities and collect revenue.

v) Overlaps in responsibilities of different stakeholders in the waste management business leading to a lot of grey areas and therefore, ineffective waste management.

These may be countered by:

- Increasing the level of public awareness in the applicable techniques in the SWM cycle.
- Building capacity of the technical personnel and improving infrastructure capacities in the local authorities.
- Commitment of financial mechanisms by way of seed funding and sustaining the systems so created.
- Conducting of monitoring programmes and data management.

7.9.1 Actions required from the international community:

a) Provision of resources to the country to assist in waste management. The resources can be in various forms including financial and technical support to the MSW management sector.
b) Appropriate technology transfer for MSW management.

7.10 Proposed Projects On technology Transfer

Viable projects under this context are in the area of mitigation and could include:

- Phased sanitary landfill technology for MSW disposal. The facility should be equipped with infrastructure, engineering, civil, environmental, mechanical designs for the various sound operational procedures.
- Upgrading of incineration technology mainly in the medical and industrial institutions. It is further recommended that the City Council of Nairobi install a central incinerator so that the institution can refer their hazardous waste for incineration. The facility should comply with the provisions of an ideal incinerator.
- A feasibility study project is carried out on the possibility of generating electricity from solid waste.
- A monitoring project on GHGs emission from wastes.
- Enhanced solid waste collection system coupled with:
    i. Source separation of waste project
    ii. Establishment of solid waste collection centres.

- Projects on recycling and composting. Already a number of youth and women groups are undertaking these activities in different parts of the city. They include City park hawkers environmental group, (composting) Kayole Environmental management association (composting /recycling), Kibera women group for environment (recycling/composting) amongst others. Many groups engage in resource recovery that they then sell to middlemen/women or to the recycling industries. The driving force in these initiatives is to earn a livelihood. Therefore given the economic scale of this cadre in the society (women/youth), it is imperative that these groups must be supported in their activities.

Expected Results

i) Economic and market penetration:

- Recycling and composting can be a source of income in small and medium scale industries as well as create job opportunities. This will spur economic growth.
- Cheaper/affordable local recycled products through import substitution.
- Reduction in operational costs for MSW management.

ii) GHGs emission reduction and other environmental benefits.

- Appropriate management standards of a sanitary landfill guarantee the reduction of methane gas generation into the environment.
- Adequate collection systems shall prohibit the burning of waste thus reducing the generation of noxious gases e.g. No_x, So_x and Co_x into the atmosphere.
- Source separation and enhanced collection systems are expected to yield a clean healthy environment.
- Use of compost manure shall enrich the nutrient cycle in the environment and increase productivity.

Data on waste shall be availed through the various projects implemented to enhance management in this sector.

7.11 Case Studies

7.11.1 Waste Management in Nairobi City

According to the Nairobi City Council, 1630 tons of waste are generated per day. About 20% of this is collected and dumped at Dandora. The Private Sector collects 32%. The typical mode of collection is through lorries or carts.
The ultimate fate of these wastes is disposal by land filling or land spreading. This practice is prone to causing nuisance and other environmental hazards to public health and safety. Traditionally, the problem of waste has always been regarded as a disposal in engineered landfills or incinerator.

7.11.2 Status of Waste Management

7.11.2.1 Solid waste

The existing MSW management practices in Nairobi are generally below average and are characterized by the following:

- Inadequate collection efficiency of the generated waste. The private companies collect 40% while the City Council of Nairobi collects 25%.
- There is no source separation of the waste that is generated into their various streams e.g. plastics, paper, glass, metals etc. This heterogeneous nature exacerbates their management practices.
- Recycling and composting technologies are very informal and rudimentary. Their level is only at 8%.
- Public awareness on waste handling and storage or disposal is still low among the low and middle-income levels.
- Illegal dumping as a way of disposal is rampant due to the open competition by the private waste operators
- There is only one final disposal point at Dandora and is now full. There also exist a serious lack of transfer stations to support the final disposal. This situation encourages illegal dumping of waste to cut down on operational expenses and overhead costs.
- The management practices at the final disposal tip at Dandora are below standards. Disposal is through open crude dumping. There is no spreading, compaction and covering with a layer of soil to minimize the smell and lower the chemical reactions that generate the GHGs. Leachate and exhaust gases are not also collected.

- Open fires also characterize the site.

Other categories of waste also find their way into the site. According to a survey conducted in 2002 by the City Council of Nairobi, over 88% of the medical institutions surveyed don't have ideal incinerators for waste disposal. Others contract illegitimate private companies to dispose of their waste.

7.11.2.2 Liquid Waste

It is the policy of the City Council of Nairobi to provide adequate sanitation services and facilities for all its residents. The implementation of the policy has been constrained by rapid population growth, mushrooming of informal settlements, vandalism and breakdown of infrastructure among others. The outdated system of bucket collection of night soil is abolished and the use of septic tanks is being improved with a vision of phasing them out in the long term.

7.11.3 Waste Management Options

Two types of wastewater treatment are applied in Nairobi viz:

1. Sedimentation ponds
2. Biological filters

The amounts of GHGs emitted from wastewater depend on the organic loading or the biological oxygen demand (BOD) and the extent of degradation under anaerobic condition. The BOD is a factor of population. Methane emissions for example occur from domestic sewerage, which are unmanaged or unmaintained under anaerobic condition.

As for the industrial wastewater the emission depends on the flow rates and the type of industry. According to studies of 1998 in this area, wastewaters in Nairobi emit fairly comparable levels of GHGs. However, it is also noted that anaerobic treatment system was started in Nairobi in 1994.

The Agro-chemical Food Industries at Muhoroni are using methane form their production process to generate all their steam requirements. This has resulted in savings of 12,000 litres of fuel per day. The government of Kenya has also established a cleaner Production Centre to help industries

produce sustainably. A number of industries have engaged full time environmental Health and Safety Officers ensuring easier environmental compliance.

7.11.4 Sedimentation Ponds

The existing technology at Ruai in Nairobi utilizes anaerobic systems and has no recovery mechanisms. The BOD generated anaerobically is fairly significant for Nairobi (0.19) as compared with other African countries (0.10). The methane emission factor under this system is also high (22) and therefore the net methane emission is considerable for harnessing into energy generation.

Table 7-1: Sewage Treatment plants (Sedimentation Ponds)

Plant	Capacity (m^3/day
Dandora	80000
Industrial Area	4500
Kahawa West	1750
Kenya Breweries	120
General Service Unit	205
Karen	455
TOTAL	87030

7.11.5 Biological Filters

Biological Filters plants are operated at Kariobangi, Eastleigh etc. making the total treatment per day therefore rise to about 317000m^3.

Table 7-2: Wastes types from Selected Health Facilities

Hospital	Waste Generation per day (kg)	Plastics (kg)	Mode of Disposal
Rhodes Chest Clinic	30	3	Burning
Ngaira Dispensary	5	1	Burning
City Mortuary	5	1.5	Burning at Langata
Chiromo Mortuary	50	5	Burning
Westlands Health Centre	5	1	Burning outside
Sara lee Health Care	13	1	Burner
Rhodes Laboratory	10	1	Burning in open
Metropolitan Hospital	40	40	One chamber Incinerator
Marie Stopes Kenya	5	1	Burner (Incinerator)
Pumwani Maternity Hospital	200	20	Burner at Langata
Nazareth Hospital	10		Burning and Burying
Mother and Child Hospital	3		Incinerator
City Council Medical Laboratories	10	10	

Source: Lacote Survey, 2003

Table 7.2 shows the typical medical waste quantities. In health facilities the waste types include syringes, needles surgical blades, paper plastics, office polythene, gloves, cotton wool, polypots for sputum and x ray chemicals.

Table 7-3: Wastes from selected Chemical Based Enterprises and Industries

Company	Type of waste	Quantities/kg	Plastics (kg)	Disposal Method
Bamburi cement Co.	Solids, paper	5	L	Contracted
Henkel Kenyatta	Chemicals, metal, plastics	924	718	Incinerator off site
Crown Berger	Various solids	150	NK	
General Motors	Various solids	1053	135	Sorting and incineration
Nation Media	Paper, waste oil solvents, paints	1015	NK	
Glaxo SmithKline	Drugs, paper plastics	234	50	Incineration using industrial diesel
Kenya Literature Bureau	Paper, plastics Inks	200	NK	Incineration
Ibera Africa Power Company	Solids, plastics paper	50 kg	5kg	Collected off site
Orbit chemicals	Drums, plastics, paper, various liquids	12	10kg	Contracted

Source: POPS project Waste Inventory, 2003

7.12 List of stakeholders

i) National

- Ministry of Environment
- Ministry of Local Government
- Ministry of Trade and Industry
- Ministry of Health
- NGOs/CBOs dealing with the environment issues
- The universities and researchers

ii) International

- UNFCCC
- UNEP
- UN-Habitat
- JICA

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CHAPTER EIGHT

8. NATIONAL CAPACITY NEEDS TO STRENGTHEN KENYA'S COOPERATION IN CLIMATE CHANGE RESEARCH AND SYSTEMATIC OBSERVATION

8.1 Introduction

Climate is one of the most important natural resources, which if properly exploited can play a crucial role in socio- economic development of the country. There is now strong evidence that climate is changing mainly on account of global warming that is brought about by increasing concentration in the atmosphere of greenhouse gases that are emitted by human activities.

Climate change is being manifested in the increasing frequency of climate variability including the frequency of extreme events. It is therefore this variability that will have the greatest impacts especially in developing countries in the African region. Any adaptation strategies must address policies and technologies that will increase the coping range of the affected communities. Climate change research should therefore be aimed at the following:-

8.1.1 Increasing our Understanding of the Characteristics of Climate Variability and Extreme Events.

Climate in Kenya varies both in time and space on account of altitude, large water bodies and the influence of large scale circulation systems such as the Inter-Tropical Convergence Zone. The climate is also influenced by global features such as El-Nino/Southern Oscillation and sea surface temperature fields in the adjacent oceans. Research should focus more on the influence of the global systems such the sea surface temperature fields and the El-Nino/ Southern Oscillation on the climate of the different regions of the country including seasonal and inter- annual variability. Global climate models that can be downscaled to the country level should form a major component of this research. In this regard institutional capacity is crucial for facilities and human resources development, data exchange international collaboration and networking.

Increasing our ability to monitor and predict the climate variability and extreme events with greater skills thereby

enhancing our confidence in the dissemination of information towards early warning and preparedness.
Monitoring of the evolution of the local, regional and the global systems that influence the country's climate is crucial to prediction of the seasonal and inter-annual variability. This information can then be used for early warning and preparedness. Research should focus on increasing the skills in monitoring, interpretation, prediction and information packaging for users in different sectors of the country's development.

Increasing our ability to characterize the impacts of the climate variability and extreme events.
Research should focus on identifying vulnerability indicators and risk and vulnerability assessment and mapping for the various socio-economic sectors of the country and scenario development.

8.1.2 Increasing our ability to formulate appropriate adaptation strategies, which are tailored to specific sectors of the economy.

There is need to develop adaptation strategies at three levels namely:

- Short- term (contingency) strategies.
- Medium-term (tactical) strategies.
- Long -term (strategic) strategies.

Research in seasonal climate variability will support development of short-term adaptation strategies such as disaster early warning and preparedness. Research for medium- term adaptation strategies will focus mainly on such areas as development of drought resistant crop varieties and management of flood plains. For long -term strategies research will focus on adaptation to the impacts associated with mean climate change conditions such as management of coastal zone of the country to respond to the expected sea level rise. Research will also address the potential for future increase in climate variability. It is expected that short-term strategies should form the foundation for the medium- term strategies and similarly the medium- term ones should lead to the formulation of long- term strategies

8.1.3 Research to enhance national capacity to undertake inventories of greenhouse gas sources and sinks.

Research in this area will focus on development of country specific emission factors in sectors such as waste management, agriculture, land use change and forestry. This research should lead to development of climate change mitigation options that are appropriate to the country's national circumstances.

8.1.4. Global Atmosphere Watch (GAW)

A Global Atmosphere Watch station has been established on Mt. Kenya. Kenyan scientists should now be able to collaborate with those from other countries in undertaking research on the changing composition of the atmosphere.

Urban climate and air quality

Urban areas in Kenya are growing rapidly on account of industrial development and rural to urban migration in search of economic opportunities. This growth will most likely have impacts on local climate and air quality. Research in this area will focus on changing urban climate and air quality and their potential impacts on the health of urban communities and those living in surrounding areas. Urban climate and air quality monitoring will form a major component of the program.

The research activities outlined above require a reasonably dense, long term and consistent observation network of the main climate parameters at national, regional and global levels. In addition because the important climate systems that affect a country are both of regional and global scales, it is crucial to have cooperation between countries in data exchange.

The commitments of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) are spelt out in article 4. In paragraph 4(g) of this article the country parties to the convention commit themselves to "Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various responses."

Unfortunately many developing countries especially in Africa do not have the financial and technical capacity to establish a reasonable density of systematic observation

network. Even the existing low-density network in many cases suffers from inconsistent observations because of lack of funds for equipment maintenance and employment of technical personnel. Unless this problem of capacity in developed countries is sufficiently addressed, global cooperation in research and systematic observation, as required by the Convention, will continue to suffer gross inadequacies with the developing countries being in highly disadvantaged position. This is more so especially considering that climate change research activities which depend on these observations will be negatively affected.

8.2 Data Needs

The data needs for research on climate change include long observation records, which are of high quality and evenly distributed to capture national and regional aspects of climate change through monitoring, detection and attribution. In addition long and continuous observations are necessary for development of climate models that can be used for vulnerability and adaptation assessments. The data include surface observations, upper air observations and specialized observations of green house gases. Climate change being a global issue requires a global network of data collecting stations. Globally, there is a network of stations dedicated to climate monitoring and research. There are three types of data collection networks namely:-

- Global Climate Observation System (GCOS) surface Network (GSN)
- GCOS Upper Air Network (GUAN)
- Global Terrestrial Observing System (GTOS) Hydrology Network (GTN-H)
- GTOS Carbon Cycle Observation Network.
- Global Atmosphere Watch (GAW)
- Ozone Stations

8.2.1 Global Climate Observation System (GCOS) Surface Network (GSN) and GCOS Upper Air Network (GUAN).

The efficiency of the surface and upper air climate network is important for climate change research and systematic observations. This contributes to the global cooperation in climate change initiatives coordinated by the Global Climate Observing System (GCOS) whose goals include: -

a) Climate system monitoring, climate change detection, and monitoring the impacts of climate change, especially in terrestrial ecosystems and mean sea level.
b) Climate application for economic development
c) Research towards improved understanding, modeling and prediction of the climate.

The GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN) are two critically important meteorological networks within the Global Climate Observing System. There are 53 GSN and 10 GUAN stations within the eastern and southern Africa region.

8.2.2 Global Terrestrial Network- Hydrology.

There is an international initiative to develop and implement a global hydrological observing network for climate. The main variables that are targeted are surface water discharge, surface and ground water storage fluxes precipitation evapo-transpiration, relative humidity and transport of bio-geochemical substances from land to ocean.

The main objectives are:

- To respond to urgent information requirements towards climate prediction, impacts and adaptation including hydrological variability to detect climate change.
- To assess water sustainability in terms of water use versus availability.
- To improve understanding of hydrological processes.

Towards these objectives The World Meteorological Organization (WMO) has initiated a World Hydrological Observing System (WHYCOS) which is being developed and implemented in the form of regional Hydrological Climate Observing System (HYCOS) projects- for example: IGAD-HYCOS, Nile- HYCOS, SADC-HYCOS and other such regional initiatives. The main aim of these projects is to assist the participating countries to improve their hydrological networks and institutional capacities.

8.2.3 Global Terrestrial Network- Carbon cycle

The greenhouse gases that are important in the enhanced greenhouse warming are long lived and are therefore well mixed in the global atmosphere. Consequently their sources and sinks have global implications.

The significance of Carbon Dioxide as a greenhouse gas is in the fact that it is the most dominant of the well-mixed gases that are emitted through human activities. It contributes about 60% of the total human induced global warming. Furthermore its concentration in the atmosphere in highly influenced by fossil fuel energy use land cover and forest cover changes.

Global Terrestrial observation Network for carbon fluxes and pools is being established at global, regional and country scales. The objective is to improve understanding of carbon cycle leading to better projection of its future concentration.

8.3 Current Systematic Observations in Kenya

8.3.1 GCOS, GSN and GUAN

In Kenya, there are 16 surface climate observing stations located at Lodwar, Garissa, Mandera, Marsabit, Jomo Kenyatta International Airport, Moyale, Kitale, Wajir, Meru, Kisumu, Nakuru, Makindu, Lamu, Voi, Malindi and Mombasa. In the proposed revised GCOS Surface Network (GSN), Lodwar, Garissa, Mandera, Marsabit, Jomo Kenyatta International Airport and Mombasa are the stations listed to be retained in GSN program. However observations from these stations are currently inadequate for the purposes of detecting and attributing climate change, monitoring and predicting climate change. The climate of Kenya is also quite complex and cannot be adequately sampled by these few stations.

The GUAN stations are highly affected by high cost of consumables and rarely perform complete programs. Kenya has three fully equipped upper air stations located at Dagorreti Corner, Garissa and Lodwar. Of these, only Dagorreti is currently operational and is making one ascent instead of two ascents per day as required due to inadequate consumables. Some of the main causes of deficiencies in the observation networks include:

- Lack of equipment
- High costs of consumables
- Inadequate capacities for the operation and maintenance of equipment.
- Lack of necessary infrastructure such electricity, access roads

- Insecurity is some of the areas where observation sites are located
- Use of obsolete and inefficient equipment for data collection at national level.
- Inadequate funds for rehabilitation and replacement of obsolete equipment.
- Lack of personnel

The Conference of Parties (COP) to the U.N. Framework Convention on Climate Change (UNFCCC) recognized the critical importance of improving observations for these reasons. Specifically, the COP, in decision 5/CP.5, has urged parties to address deficiencies in climate ***observing systems*** in developing countries. The COP has placed particular emphasis on addressing deficiencies in these countries with a view to enable them to collect, exchange, and utilize data on a continuing basis in pursuance of UNFCCC goals and to allow them to develop the necessary capacity mandate in the area of critical meteorological observations.

Global Terrestrial Network-Hydrology

There is a fairly dense hydrology observation network in the major drainage basins in the country especially for surface discharge and water storage fluxes. Kenya is a participant in the planned IGAD and Nile HYCOS projects.

8.3.2 Global Atmosphere Watch (GAW) station

The concern for climate change through global warming has led many nations to participate in assessing the current state and trends of the chemical state of the atmosphere. It is for this reason that WMO initiated new GAW stations in 1989. The Global Environmental Facility (GEF) of the World Bank provided finances for the implementation of six (new) GAW stations in the world, located in Brazil, China, Algeria, Kenya, Indonesia and Argentina. In the African region, there are 3 GAW stations. The one in Kenya is located on Mt Kenya and operated by the Kenya Meteorological Department. It is at an altitude of 3897m. The station was established to achieve the following:

- Systematic observation of atmospheric chemical composition and related physical parameters on a regional to global scale.
- Analysis and assessment in support of environmental conventions and future policy development.
- Development of predictive capability for future atmospheric states.

The specific systematic observations currently being made at the station, which are relevant to climate change assessment, are:

- Meteorological measurements
- Surface Ozone
- Carbon monoxide
- Aerosols

Measurements of greenhouse gases such as Carbon Dioxide, Methane and Nitrous Oxide are presently not being made on account of logistical problems associated with transportation of samples to laboratories abroad for analysis. Apart from Kenya, it is only South Africa within the eastern and southern Africa region running GAW stations.

8.3.3 Nairobi Ozone sounding Stations

A complementary station to the Mt. Kenya global station is the Nairobi Ozone Sounding Station, started under the support of Swiss Government through WMO and operated by KMD. This is a vertical ozone data collecting station. Department of Meteorology, University of Nairobi has also been operating a Dobson Ozone Spectrophotometer that monitors the total Ozone layer since 1984.

8.3.4 Data processing and storage

Data management influences results of any research. Currently computers dominate the media for data storage. The computer technology evolves rapidly and majority of developing countries are not able to cope with the rapid evolution. The changes in computer technology have led to enormous volumes of data to be inaccessible. Such data frustrates climate change research since they reduce the period of the available data and also reduce the spatial coverage of stations with good data. Efforts are still being made to recover data stored on computer tapes. In addition, large volumes of KMD data are still stored in paper forms that are in danger of deteriorating or being lost. Efforts are therefore being made to digitize this data and store them into computer forms. In its data processing activities, the department subjects all the climate data to standard quality control procedures to ensure that high quality available.

Climate change research and prediction require high computing capacity. At the moment, the only computer with adequate capacity to run climate change models is located at the Drought Monitoring Center in Nairobi (DMCN). It is

therefore important that the country and region take advantage of the DMCN computing capacity to address climate change needs.

8.3.5 International cooperation in data exchange

The cooperation in international data exchange forms the major basis for the existence of the World Meteorological Organization (WMO) and GCOS. Localized changes in climate can affect the entire globe through the Global Climate System. Hence a global approach to climate monitoring and exchange is essential. This is achieved through the Global Telecommunication System (GTS). Kenya hosts the Regional Telecommunication System (RTH) responsible for data collection and exchange in eastern and southern Africa. The major cause of non-availability of data from the region and country is the poor performances of telecommunication links. These limitations affect climate monitoring and prediction, not only for the country or region, but also for the entire global community. SBSTA [FCCC/SBSTA/2001/C.14] noted with concern the continued deterioration of the global climate observing systems. The IPCC Third Assessment Report also emphasizes the same concern. The conference of the parties (COP) to The UN Framework Convention On Climate Change (UNFCCC) has encouraged parties to actively support capacity-building activities in developing countries to enable them collect, exchange, and utilize data to meet local, national, regional, and international needs (Decision14/CP.4), and the need to identify priority capacity-building needs related to participation in systematic observations (Decision 5/CP.5). The projections for climate change trends cannot be realistic unless data from all parts of the globe is available on time for inclusion in the data input for the global model socio-economic impacts and validation of the model outputs. The efficient climate monitoring and prediction would reduce the negative impacts of extreme climate events such as food insecurity, public safety, enhanced poverty, economic growth stagnation, poor health and social conflicts amongst many others.

8.4 Institutional Set-Up

There are three institutions in Kenya that are mainly involved in research and systematic observations in the area of climate change as shown below.

Kenya Meteorological Department (KMD) is the institution in Kenya that has the mandate for systematic observation of

climate and climate change. It is responsible for installation and maintenance of surface and upper air observing systems. It is also responsible for collection, analysis and storage of meteorological data including global data exchange. In addition the department conducts applied research in various areas of weather and climate. The department has a compliment of about 120 class 1 meteorologists including 5 PhD and 41 MSc holders.

8.4.1 Drought Monitoring Center - Nairobi (DMCN) is a specialized institution of IGAD. It undertakes climate monitoring and seasonal predictions of climate stress for the Greater Horn of Africa region (GHA) and thereby providing climate information that can be used for early warning by the countries in the region. The center has established a historical climate data bank for the region that is continuously updated through timely reception and archival of near real time climate data from the participating countries. The historical data sets have been used to, among other things develop the seasonal forecast models for the GHA region and for individual countries as well as generate national climate atlases that include risk zone maps. The near real time data are used for monitoring of the climate conditions in the region with a view of identifying any climate stress signals as soon as they commence. The center conducts climate research towards improving the seasonal forecast skills including climate impacts assessment. Most of the staff at the center is seconded from KMD, University of Nairobi and National Meteorological and Hydrological Services in the GHA.

8.4.2 Department of Meteorology, University of Nairobi has the responsibility of training of the World Meteorological Organization (WMO) class 1 meteorological personnel (Bsc. and Post Grad. Dip.). The department is a regional training center for east and central African countries. The department also conducts research training leading to Msc. and PhD. degrees. Its staff also undertakes applied research in climatology including climate variability and change and their impacts on various socio-economic sectors. The department has a compliment of 15 academic 14 of which are PhD holders.

The three institutions described above have developed strong links, which have led to close collaboration in areas of training, research and systematic observations of climate variability and change.

8.5 Capacity Needs at National Level

Many stations in the country are not functioning adequately because funds are insufficient to buy new modern equipment, to carry out day-to-day operations, or to buy spare parts. In addition, there is too few qualified staff to operate and maintain equipment. Specialized observations of Carbon fluxes and pools is not being undertaken on account of lack specialized equipment and qualified staff.

8.5.1 Training needs.

Human capacity has to be developed in such areas as the systematic observations of climate change using the existing National and Global Networks. It is possible to make improvements on the existing institutional capacity in Kenya in order to participate in Climate Change Research and Systematic Observation.

GAW and carbon cycle observations are more specialized and the personnel need to be trained specifically for these activities. Therefore, capacity building by training for monitoring including sampling techniques, data analysis and data management is very necessary.

Urban climate and air quality monitoring in major urban areas is very crucial. Capacity is needed to develop urban emission inventories and carry out urban climate studies, air pollution modeling, monitoring and forecasting.

The majority of climate scientists have the general knowledge. There is a need for specialized training in aspects such:

- Climate variability and change studies
- Specialized training on climate change in areas such as impact assessment, scenario developments, vulnerability assessments etc
- Climate change model development and operationalization.
- Specialized equipment maintenance and any other relevant courses.

The training for research especially in the area of modeling for impacts assessment should be at post graduate level while in a number of specialized areas short term training courses and attachments to specialized institutions is a more practical option. University of Nairobi has the capacity to provide training in meteorology at both under-graduate and post-graduate levels. Moi University has a Department of Environmental Studies, which

can be utilized to some training needs. Short term specialized research and technical training courses can be undertaken at specialized institutions in other countries. Collaboration therefore needs to be developed with such institutions.

8.5.2 Equipment Needs

8.5.2.1 GSN, GUAN Network

Climate monitoring is an expensive investment. The majority of equipment required is expensive and not available locally. Stations like GAW and Ozone stations have been acquired through external support. The computers required to study climate change are expensive and as mentioned earlier the only institution having a computer that can handle models for understanding the processes involved in climate change is the DMC, Nairobi. There is need to improve data collection from existing GSN and GUAN network by provision of adequate and predictable funding for maintenance operational expenses.

In addition to observation and data processing equipment needs, the equipment to transfer the data are also expensive. The current Automatic Message Switching System in the department was procured at about Ksh.100million it is now due for replacement after operating for over ten years. The cost of leased telecommunication links is also very high. At the moment the department is installing a VSAT to support telecommunication needs.

8.5.2.2 GTN-Hydrology

There is need to improve the density of surface hydrological observation network in the country in order enhance information on hydrologic cycle towards better climate prediction, impacts and vulnerability and adaptation assessment including water quality and sustainability. In addition there is need monitor the trends of Mt. Kenya glaciers and lake levels.

8.5.2.3 Carbon Cycle Observations and Research

In order for Kenya to participate effectively in observation and research on Carbon cycle there is need to establish carbon fluxes observation sites preferably within the Global Surface Network stations. However these equipment are expensive and hence the need for developing partnership with institutions that are undertaking carbon

cycle observations in order to build the required research and technical capacity. In particular, there is need to have a mobile carbon flux tower for CO2 measurements in a number of areas with different land use characteristics.

8.5.2.4 GAW Station

There is need for equipment for:

- Measurement greenhouse gases instead of the samples requiring to be sent abroad for analysis.
- Measurement of aerosol optical depth (Sun-photometer).
- Communication facilities linking the GAW station to world data centers and data quality assurance/scientific activity centers are crucial. In this regard, Internet connectivity at the GAW station is recommended.

8.5.2.5 Automatic Weather Stations

Use of automatic weather stations in remote areas can increase the density of surface observation network. Although these equipment have substantially high initial cost, they can be operated at much lower costs in terms of maintenance and personnel. There is therefore need to install a number of these equipment in areas where data availability is crucial and is not covered by the existing network.

8.5.2.6 Urban Climate and Air Pollution Monitoring

As is the case with many other developing countries, Kenya's urban centers are growing rapidly in spatial extent, population and human activities leading to changes in local climates and air quality. Urban climate and air pollution monitoring is therefore crucial for the study of climate change impact studies. However this activity has not been undertaken in a systematic way in the country because of lack of equipment. There is need to install appropriate equipment in major urban areas to enable studies of impacts of climate change on urban environment, public health and safety.

8.5.2.7 Volunteer Observer Program

This is a program in which individuals, schools or companies volunteer to make observations on behalf of the national weather services. Volunteer observers are then trained in observation techniques and then provided with appropriate equipment for routine climate parameters. This program can greatly enhance the density of systematic observation network in the country if it is implemented in a sustainable way. In this regard the equipment should be

robust, user friendly and requiring minimum training to operate. Kenya Meteorological Department (KMD) will need to design and mount short training courses for the volunteer observers and also prepare equipment operation and maintenance manuals.

8.5.2.8 Institutional Collaboration.

Climate change research and systematic observation are multidisciplinary requiring collaboration between institutions that are either specialized or are responsible for the various sectors in the country. Some of the main institutions that could develop collaboration include: -

- Kenya Meteorological Department (KMD).
- Drought Monitoring Center-Nairobi (DMCN).
- University of Nairobi (UON).
- Moi University (MU).
- Kenyatta University (KU).
- Kenya Agricultural Research Institute (KARI).
- Kenya Forestry Research Institute (KEFRI).
- Kenya Medical Research Institute (KEMRI).
- Ministries responsible for: Environment and Natural Resources, Agriculture, Water Development, Energy, Transport and Communication, Industry.
- Kenya Association of Manufacturers (KAM).
- Kenya Industrial Research and Development Institute.

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