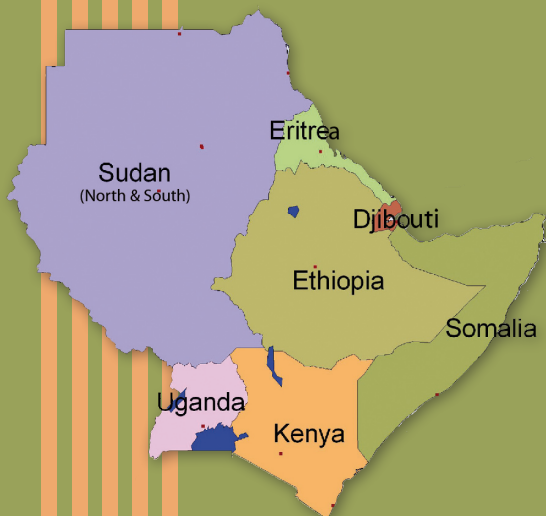


Mapping, Assessment & Management of Transboundary Water Resources in the IGAD Sub-Region Project



Volume III

ENVIRONMENTAL COMPONENT



INTERGOVERNMENTAL AUTHORITY
ON DEVELOPMENT



AFRICAN WATER FACILITY



SAHARA AND SAHEL OBSERVATORY

Mapping, Assessment & Management of Transboundary
Water Resources in the IGAD Sub-Region Project

Volume III

ENVIRONMENT COMPONENT

An assessment of the key environmental issues affecting
the IGAD sub-region

December 2011

Study conducted with the support of:



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PREFACE

The IGAD sub-region represents one of the marginal regions of the world in terms of rainfall available for natural vegetation growth and crop production. About 80% of the IGAD sub-region is arid and semi arid with low level of water use. It has a population estimated at **206 million in 2010** and projected to reach **462 million in 2050** in an area of **5.2 million km²**.

The most obvious manifestation has been periodic droughts and desertification that have consigned millions to perpetual poverty and deaths. The populations derive their livelihoods from water and land based primary production activities such as nomadic pastoralism and subsistence agriculture in a region where rainfall variability is high. The sub-region is the home of the greatest numbers of pastoral communities estimated to be about **17 million**. Dependable water availability is therefore vital to the development of the region.

The mounting concerns over water scarcity in the IGAD sub-region have focused attention to several socioeconomic challenges of water resource management.

Firstly, as the sub-region expects to advance economically and socially, the demand for water will increase as a result of population growth, rising incomes, changing dietary patterns, urbanization and industrial development. While demand will increase in all sectors, agriculture will account for the bulk of the water and will therefore be the focal point for adjustment of demand pressure.

Secondly, there are concerns as to whether the IGAD sub-region will have enough water to meet the food security needs of a rapidly growing population. Along with food security, water security has also become a fundamental issue for human development in the sub-region

While it is a fact that water occupies pivotal position in development in the IGAD sub-region, none of the **member countries has adequate information** to manage their water resources for the attainment of economic efficiency and equity in water allocation for different uses. Yet, four IGAD countries namely **Eritrea, Kenya, Djibouti and Somalia** are in the category of those experiencing water scarcity i.e. with **less than 1000 m³ per person per year** or less.

Indeed by the year 2025 even Ethiopia and Uganda which are presently with adequate water will be water stressed (1000-2000 m³/person/year) while Djibouti, Eritrea, Kenya, Somalia and Sudan will be in water barrier situation «500 m³/person/year » and therefore water will be limiting any sustainable development.

None of the IGAD Member States has at the present time water per capita necessary for industrial development (2400 m³/day). This lack of water will severely constrain food production, ecosystem maintenance and economic development among other needs and uses.

Water resources link the IGAD Member states internally and externally with adjacent regions. Six transboundary river basins and six transboundary aquifer systems have been identified in this stage of the IGAD sub-region study. **The ratio of water demands to available supply averages which is 9% in 2011 will increase to 15% in 2031** as projected by this study which is known as “*Mapping, Assessment and Management of Transboundary Water Resources in the IGAD Sub-region Project*”. However, there are specific problems that call the need for adequate knowledge of surface and ground water resources.

This Study (the first sub-regional study) has provided a platform for refocusing efforts within the sub-region towards better quantification and understanding of the extent of water scarcity and other water related factors that impact socioeconomic development in the sub-region. The most significant of the drivers of water demand in all sectors is population, which in the sub-region is projected to increase by 165% between 2010 and 2030, and by 136% between 2030 and 2050. This study demonstrates that these increases will create significant increases in water withdrawals for domestic supply and for industry.

The other significant sector is agriculture, which combines irrigation and livestock. Again here population is the most important parameter of change, driving the demand for food and hence the need to raise agricultural productivity through irrigation development.

The regional process has highlighted the **low level of water use** and hence of water security currently estimated as about 3% of the annually renewable water resources as a basic indicator of the overall lack of water infrastructure development to ensure water security for the social and economy and environmental use. The IGAD sub-region is one of the most vulnerable areas to climate variability and recurrent droughts.

Hence, there is need to further understand in depth the environmental situation and consolidate IGAD capacities to monitor the linkages between climate and the water system along with identification and mapping of the water resources and the major risks associated with degradation, pollution and water quality deterioration. Policies, strategies, and objectives of cooperation and how to achieve them should be set out in a second stage of the IGAD project study.

It is important to note that the IGAD project was implemented at national and sub-regional levels with active participation of the focal national institutions by employing national and regional consultants. The project coordination is done by OSS with the establishment of national coordination units in the focal national water institutions of the IGAD Member States. Steering Committee of the project was in place and the regional coordination and facilitation was done by IGAD.

We would like to thank everyone who contributed to the success of this project: the Ministries in charge of Water and national institutions, the IGAD and OSS cooperation partners (particularly the African Water Facility), the national teams, national and

international consultants, the project team within the Executive Secretariat of OSS and The IGAD Secretariat.

Our satisfaction was to pass the ownership of all project results by national teams and the establishment within the Executive Secretary of IGAD powerful tools to ensure the continuity of the project.

This final project report is made up of 7 individual documents namely

- Introduction, Overview and General Recommendations
- Volume 1: Institutional Framework Component Report
- Volume 2: Socioeconomic Component Report
- Volume 3: Environment Component Report
- Volume 4: GIS/Database Component Report
- Volume 5: Water Resources Modelling/Hydrology Component Report
- Volume 6: IWRM Component Report

We also thank SEREFACO Consultants Limited and its team for the excellent work carried out despite all the difficulties encountered particularly the lack of reliable data.

The Executive Secretary of OSS
Dr. Ing. Chedli FEZZANI

The Executive Secretary of IGAD
Eng. Mahboub Mohamed MAALIM



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LIST OF ACRONYMS

ASAL	Arid and semi-arid land
BCM	Billion cubic metres
BOD	Biochemical Oxygen Demand
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CITES	Convention on International Trade in Endangered Species
COP	Conference of Parties
DLDD	Desertification, Land Degradation and Drought
EAC	East African Community
EEA	Eritrean Environmental Agency
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act (Kenya)
ENSAP	East Nile Subsidiary Action Programme
FAO	Food and Agriculture Organization of the United Nations
FEWSNET	Famine Early Warning Systems Network
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIS	Geospatial Information System
HCENR	Higher Council for Environment and Natural Resources
ICPAC	IGAD Climate Prediction and Applications Centre
ICT	Information and Communications Technology
IDPs	Internally Displaced People's Camps
IGAD	Inter-government Authority on Development
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
KWS	Kenya Wildlife Service
LDCF	Least Developed Countries Fund
LPG	Liquefied Petroleum Gas

MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreement
MEAs	Multilateral Environmental Agreements
MLWE	Ministry of Land, Water and Environment (Eritrea)
MoARD	Ministry of Agriculture and Rural Development (Ethiopia)
MoWR	Ministry of Water Resource Hydrology
NAPA	National Adaptation Programmes of Action
NBI	Nile Basin Initiative
NBSAP	Eritrea Biodiversity Strategy and Action Plan
NCCRS	Kenya National Climate Change Response Strategy
NELSAP	Nile Equatorial Lakes Subsidiary Action Programme
NMA	(Ethiopia)
NMA	National Meteorological Agency
NOAA	National Oceanic and Atmospheric Administration
NPPO	National Plant Protection Organization
NWSC	National Water and Sewerage Corporation (Uganda)
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty (Ethiopia)
PEAP	Poverty Eradication Action Plan
PMA	Plan for Modernisation of Agriculture
PPM	Parts per million
RPPO	Regional Plant Protection Organization
RVF	Rift Valley Fever (a disease of cattle)
RVLB	Rift Valley Lakes Basin
SCCF	Special Climate Change Fund
SSO	Sahara and Sahel Observatory
SWALIM	Somalia Water and Land Information Management
TFG	Transitional Federal Government (Somalia)
TOR	Terms of Reference
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention for Combating Desertification
UNCED	UN Conference on Environment and Development (Rio Summit)
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey

UWA	Uganda Wildlife Authority
WPAs	Wildlife Protected Areas



EXECUTIVE SUMMARY

This Phase 3 Environmental Component Report is the culmination of the assignment that took a team of six Specialists to prepare. The Report is a self-contained document i.e. all the information in the other reports – Phase 1 and Phase 2 – is fully reflected in this report; one does not need to refer to the other reports in order to use this Report. The Report includes coverage and analysis of Eritrea and Somalia on top of the other IGAD countries.

The report is built out of three key environmental thematic areas: 1) drought and desertification; 2) flooding and erosion risk and 3) water quality and pollution. These three areas were covered at national and sub-regional levels, meaning that the volume contains analysis of each of the 7 IGAD Member States and a general sub-regional analysis for each thematic area.

The basic documents for study were the national reports prepared for the SSO Project by consultant; the National Adaptation Programmes of Action prepared by each State for the UNCCD; the Initial National Communications to the UNCCD prepared by each State and a raft of general information obtained from a number of portals.

Eritrea and Somalia were only included in the Study at the Validation Workshop for Phase 2 and it was a challenge to prepare an analysis that reached the levels for the other IGAD countries. We were however not able to obtain full information and data on some of the areas that were critical for the progress: both Eritrea and Somalia did not have National Environmental Reports in the three thematic areas. The available information inadequately covered the thematic areas. Somalia has not prepared a NAPA or even the Initial Communication documents. However, the SWALIM website proved to be a valuable source of information on Somalia.

The depth and breadth of the information in this report, being largely one of literature review, can only be as good as the sources that are quoted herein. The transboundary aspects of the Study were not dealt with to the required depth since there was a shortage of information on the basins from the National Focal Point Offices. There is virtually no transboundary analysis in the reports so far studied, much less modelling of the effects of the three scenarios over the next few decades. The models given in the reports are those for greenhouse gases and climate change and variability; even this is not consistent in quality and quantity.

Large areas of the IGAD sub region are arid, semi-arid or desert with more than 50% of their land mass regarded as arid or semi-arid in some of the countries. The impacts of climate

change and variability are therefore felt directly by these countries, especially the most vulnerable rural populations. The arid and semi-arid lands (ASALs) are mainly inhabited by the itinerant pastoralists and nomads, some of who combine pastoralism with agriculture. However their habitats are being denuded of vegetation – especially the forests – leading to wider environmental impacts such as land degradation, reduction in ground and surface water resources, pollution of the soils and waters, increased soil erosion and failure by the ecosystems to perform their roles in a sustainable manner.

The rapid population growth and poor socioeconomic structures in these countries make the future bleak for the vulnerable populations. In the case of Somalia, the extended civil conflict and the devastating flash floods combine to wreak havoc on the helpless population in the rural areas. Even the more peaceful north suffers from the flash floods which strike even after little rains due to the inability of the soils and terrain to absorb and retain rainwater.

The mitigation actions for these flash floods include the setting up of storage facilities for the rainwater in dams, rainwater harvesting tanks and by reducing the slopes of the hillsides.

Pollution of water is increasing in all the IGAD countries at an alarming rate. For countries such as Eritrea, Somalia, Djibouti, Sudan and Kenya, where the exploitation of groundwater to sustain life in the ASALs is practised on a large scale, salinisation of water sources has been experienced. The same effects are also felt in the large irrigation projects in Sudan, Kenya and Ethiopia – the methods used for much of the irrigation easily create water logging and salinisation of the soils.

The IGAD region is experiencing a surge in oil discoveries and will face the problems of increased pollution from exploration and exploitation of oil from the countries. Sudan is already experiencing severe problems with produced water during the exploitation of oil while Uganda is soon moving to the stage of producing oil in the Albertine Graben of Western Uganda.

An important footnote to this report is the fact of the independence of South Sudan from the Sudan which took place on 9 July 2011. This Report gives information that is valid for the combined State of Sudan. There was no opportunity to disaggregate the data to the two separate independent countries at the time of finalising this Report.

1

INTRODUCTION TO THE ASSIGNMENT

1. SCOPE OF THE ENVIRONMENTAL COMPONENT OF THE ASSIGNMENT

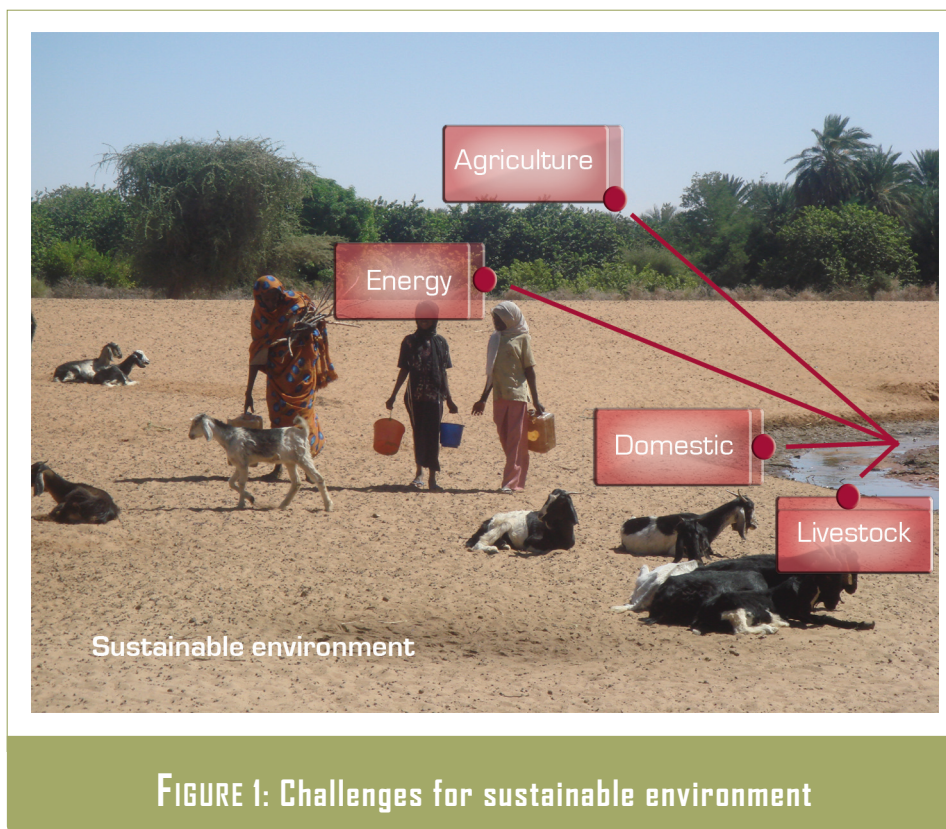
1.1. Scope of the assignment

The terms of reference defines the scope of the environmental component of the assignment.

‘The Consultant shall identify and adequately address and map the key challenges linked to water resources management in the sub-region (Figure 1). This will be based on the outputs of the national studies and supplemented by the regional assessment. The first task will be to critically review the national studies related to the environmental assessment and analysis so that it can be complemented by other sources of data and information as basis of this Study. The environmental assessment and analysis shall address issues related to:

- *Identifying key environmental issues at national and at sub-regional levels.*
- *Assessment of drought effects and climate variability.*
- *Assessment of flooding and land degradation.*
- *Assessment of water pollution and quality.*
- *Analysis of Impact of current and future demographic trends on the water resources of the sub-region.*
- *Undertaking analysis of coping strategies and actions with the formulation of sub regional coping strategies.*
- *Defining mitigation measures for controlling and improving the key environmental issues that will be bases for sub-regional decision making.*
- *Formulation of sub-regional environmental management plan.*

The data and information as related to the environmental component, which will be made available by the national consultants include environmental impact assessments on water resources development projects (domestic water supply, irrigation, industrial use and others) and as well as analysis and parameters indicating pollution aspect; land degradation data (possibly in the form of digital maps); erosion hazard maps in digitized form; drought prone areas and data related to the recurring droughts and land use/cover digital maps and other relevant data and information.’



1.2. Scope for the Phase 3 report

The title of Phase III is Planning and Implementation. The inception report and Phase I and II Reports have already been presented and accepted by the Client.

From the terms of reference, the following are the issues that must be addressed by the Phase III Report:

1. Formulation of strategies for enhancing regional cooperation (we shall contribute to the wider presentation with the environmental strategies).
2. Development of a framework and guidelines for regional procedures and coordination mechanisms for information production, dissemination and sharing.
3. Conducting awareness and sensitisation workshop at sub-regional level for decision makers.

1.3. Layout of the Phase 3 report

This Phase 3 Environmental Component Report is the culmination of the assignment that took a team of six Specialists to prepare. The Report is a self-contained document i.e. all the information in the other reports – Phase 1 and Phase 2 – is fully reflected in this report; one does not need to refer to the other reports in order to use this Report. The Report includes coverage and analysis of Eritrea and Somalia on top of the other IGAD countries.

The report is built out of three key environmental thematic areas: 1) drought and

desertification; 2) flooding and erosion risk and 3) water quality and pollution. These three areas were covered at national and sub-regional levels, meaning that the volume contains analysis of each of the 7 IGAD Member States and a general sub-regional analysis for each thematic area.

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Eritrea and Somalia were only included in the Study at the Validation Workshop for Phase 2 and it was a challenge to prepare an analysis that reached the levels for the other IGAD countries. We were however not able to obtain full information and data on some of the areas that were critical for the progress: both Eritrea and Somalia did not have National Environmental Reports in the three thematic areas. The available information inadequately covered the thematic areas. Somalia has not prepared a NAPA or even the Initial Communication documents. However, the SWALIM website proved to be a valuable source of information on Somalia.

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The Phase 3 report is laid out as follows:

- **Chapter 1** is this Introduction.
- **Chapter 2** gives the general analysis of drought and desertification, climate change and variability and their impacts on communities. The analysis is more detailed than is expected from the National Reports since it aims to get a broader perspective to the impacts of drought and desertification.
- **Chapters 3 to 7** respectively cover the assessment of the impact of drought and desertification on Djibouti, Kenya, Ethiopia, Sudan and Uganda.
- **Chapter 8** gives the impact of key environmental issues in Eritrea. Since there is a general lack of information on Eritrea (they did not prepare National Reports), the little that could be gleaned from various sources is found in this chapter.
- **Chapter 9** gives the impact of key environmental issues in Somalia. Since there is a general lack of information on Somalia (they did not prepare National Reports), the little that could be gleaned from various sources is found in this chapter.
- **Chapters 10-14** cover the assessment of the impacts of flooding and erosion risk in all the IGAD countries with the exception of Eritrea and Somalia.

-
- **Chapters 15-19** cover the assessment of the impacts of pollution and quality in the five countries of IGAD with the exception of Eritrea and Somalia.
 - **Chapters 20-22** cover the three thematic areas over the IGAD member states at the sub-regional level.
 - **Chapter 23** gives the Environmental Management Plan where solutions to the identified environmental challenges may be investigated.
 - **Chapter 24** highlights some of the multilateral environmental agreements (MEAs) that are recommended for adoption and domestication in the IGAD sub-region.
 - **Chapter 25** gives the conclusions and recommendations of the environmental component of the assignment.

2. APPROACH AND METHODOLOGY

The approach and methodology to the environmental component is by literature review and analysis, expert consultations and compilation of resources used in the assignment. There are training sessions arranged as part of the assignment and within these, the Consultant sought to get clarification on the status of these river basins and the key environmental issues therein.

The Consultant has obtained numerous environment related literature from the national reports prepared for the assignment from the Client and from national institutions and international organisations. This literature has largely been reviewed.

The approach to the transboundary environmental analysis is informed by the presence of international conventions and agreements that most of the IGAD countries belong to. We approach the environment institutional framework for cooperation in the same vein – cooperation should follow established principles set by the international agreements and conventions that IGAD members belong to.

Identification of areas of cooperation is also to follow these same principles.

3. APPRECIATION OF THE STUDY

One of the key Strategic Objectives of the IGAD Environment Strategy 2007¹ is:

Strategic Objective 1: To improve the framework for environmental and natural resources governance in the IGAD region.

Outcome 1.1: The process of harmonizing environment and natural resources policies supported and led.

Outcome 1.2: Awareness creation promoted and the process of developing appropriate strategies and concepts in transboundary resources management supported and guided.

Outcome 1.3: Member states assisted to comply with the provisions of, and benefit from, the international instruments.

¹. IGAD Environment and Natural Resources Strategy, 2007.

The other Strategic Objectives are:

Strategic Objective 2: To develop information required for sound environmental and natural resources management in the IGAD region and make it readily available.

Outcome 2.1: Environmental and natural resources information provided at the regional level.

Outcome 2.2: Timely exchange of environmental and natural resources information promoted.

Strategic Objective 3: To enhance capacity of member states for improved environmental and natural resources management in the IGAD region.

Outcome 3.1: Capacity of member states and IGAD staff in the use of environmental assessments, crucial for promoting regional cooperation built.

Outcome 3.2: Suitable incentives and disincentives measures to complement regulatory enforcement identified.

Outcome 3.3: A more focused forum targeting the environment and natural resources of civil society organizations and non-state actors established.

Strategic Objective 4: To enhance the capability for environmental and natural resources research and development in the IGAD region.

Outcome 4.1: Research agendas identified and the creation of linkages and networks in the area of environment and natural resources management facilitated.

Outcome 4.2: The capacity of the member states for accessing potential incremental financial resources built.

The present outcomes of the assignment are in line with the above Strategic Objectives of IGAD.

While the Agreement Establishing IGAD identified some twenty areas of cooperation among the member states, the following three priority areas were selected as the immediate entry points for cooperation:

- Food security and environmental protection;
- Conflict prevention, management and resolution; and
- Economic cooperation and integration.

Environmental protection is therefore on top of the agenda in the IGAD sub-region.

EFFECTS OF DROUGHT AND CLIMATE VARIABILITY

1. BACKGROUND INFORMATION ON DESERTIFICATION

1.1. Understanding desertification

Desertification is defined by the U.N. Convention to Combat Desertification (UNCCD) as *“land degradation in arid, semiarid and dry subhumid areas resulting from various factors, including climatic variations and human activities.”* Land degradation is in turn defined as *the reduction or loss of the biological or economic productivity of drylands.* Desertification takes place worldwide in drylands, and its effects are experienced locally, nationally, regionally, and globally. Drylands occupy 41% of Earth’s land area and are home to more than 2 billion people—a third of the human population in the year 2000. Drylands include all terrestrial regions where water scarcity limits the production of crops, forage, wood, and other ecosystem provisioning services.

The greatest vulnerability is ascribed to sub-Saharan and Central Asian drylands. In three key regions of Africa—the Sahel, the Horn of Africa, and Southeast Africa—severe droughts occur on average once every 30 years. These droughts triple the number of people exposed to severe water scarcity at least once in every generation, leading to major food and health crises².

Desertification is a result of a long-term failure to balance demand for and supply of ecosystem services in drylands. The pressure is increasing on dryland ecosystems for providing services such as food, forage, fuel, building materials, and water for humans and livestock, for irrigation, and for sanitation. This increase is attributed to a combination of human factors and climatic factors. The former includes indirect factors like population pressure, socioeconomic and policy factors, and globalization phenomena like distortions to international food markets and direct factors like land use patterns and practices and climate-related processes. The climatic factors of concern include droughts and projected reduction in freshwater availability due to global warming.

Policies to replace pastoralism with sedentary cultivation in rangelands can contribute to desertification. Policies and infrastructure that promote farming in rangelands that cannot sustain viable cropping systems contribute to desertification. The majority of

² As quoted in the Millennium Assessment ‘Desertification Synthesis’ of the Millennium Assessment Organisation available at <http://www.millenniumassessment.org/en/index.aspx>.

dryland areas (65%) are rangelands that are more suited to sustainable pastoralism than crop production. For example, nomadic pastoralism is a rangeland management practice that over the centuries has proved to be sustainable and suited to the ecosystem carrying capacity. Sedentarization of nomads in mar–ginal drylands and other limitations to their transboundary movement lead to desertification because they reduce people’s ability to adjust their economic activities in the face of stresses such as droughts.

Land tenure practices and policies that encourage land users to overexploit land resources can be important contributors to desertification. When farmers and herders lose control or long-term security over the land they use, the incentives for main–taining environmentally sustainable practices are lost. Problems of water scarcity, groundwater depletion, soil erosion, and salinisation have all been recognized as outcomes of deeper policy and institutional failures. Security of tenure does not necessar–ily imply private property rights; many long-established collec–tive and community-based management practices have operated quite effectively. In successful communal systems, greater transparency and fairness in the allocation of resources to all stakeholders is essential (Figure 2). Private land tenure systems in drylands have been less successful in ensuring that pastoralists have access to various ecosystem services such as provisioning of water and pasture.



FIGURE 2: Need to allocate water

Frequent and intensive fires can be an important contributor to desertification, whereas controlled fires play an important role in the management of dryland pastoral and cropping systems. In both cases, the use of fire promotes the service of nutri–ent cycling and makes nutrients stored in the vegetation available for forage and crop production. Fires can be

an important cause of desertification in some regions when they affect natural vegetation. Excessive intensity and frequency can lead to irreversible changes in ecological processes and, ultimately, to desertification. The consequences of such changes include the loss of soil organic matter, erosion, loss of biodiversity, and habitat changes for many plant and animal species.

1.2. Combating desertification

Tailored to the degree of aridity, interventions and adaptations are available and used to prevent desertification and to restore, where needed, the capacity of the dryland ecosystems to provide services. Increased integration of land and water management is a key method for desertification prevention. Increased integration of pastoral and agricultural land uses provides an environmentally sustainable way to avoid desertification. Prevention is a much more effective way to cope with desertification, because subsequent attempts to rehabilitate desertified areas are costly and tend to deliver limited results³.

Desertification can also be avoided by reducing the stress on dryland ecosystems by introduction of alternative livelihoods that have less of an impact on dryland resources and by creation of economic opportunities in urban centres and areas outside drylands.

Combating desertification and its related economic conditions will likely fare better when proactive management approaches are used. Combating desertification yields multiple local and global benefits and helps mitigate biodiversity loss and human-induced global climate change. Environmental management approaches for combating desertification, mitigating climate change, and conserving biodiversity are interlinked in many ways. Therefore, joint implementation of major environmental conventions can lead to increased synergy and effectiveness, benefiting dryland people.

Effectively dealing with desertification will lead to a reduction in global poverty. Addressing desertification is critical and essential for meeting the Millennium Development Goals successfully. Viable alternatives must be provided to dryland people to maintain their livelihoods without causing desertification. These alternatives should be embedded in national strategies to reduce poverty and in national action programs to combat desertification.

More people in drylands than in any other ecosystem depend on ecosystem services for their basic needs. Crop production, livestock (Figure 3) and dairy production, growth of fuel wood, and construction materials all depend on plant productivity, which in drylands is constrained by water availability. Thus it is the dryland climate that constrains viable livelihood opportunities. Practices like intensified cultivation in areas that do not have an adequate level of supporting services (soil fertility, nutrients, and water supply) thus require adjustments in management practices or costly imports of nutrients and water.

Fluctuation in the supply of ecosystem services is normal, especially in drylands, but a persistent reduction in the levels of all services over an extended period constitutes desertification. When the resilience of a dryland ecosystem is impaired and it does not return

³ Ibid, page 10.

to the expected levels of service supply after the stress is removed, a downward spiral of degradation — in other words, desertification— may occur. The mechanisms linked to this phenomenon include: excessive loss of soil, change in vegetation composition and reduction in vegetative cover, deterioration of water quality and reduction in available quantity, and changes in the regional climate system.



FIGURE 3: Example of livestock in sudan

Transformation of rangelands and silvo-pastoral dryland systems to croplands increases the risk of desertification due to increased pressure on the remaining rangelands or to the use of unsustainable cultivation practices. Although range-lands are resilient under traditional mobile grazing practices—commonly called transhumance—in response to seasonal changes, reduced transhumance leads to overgrazing and range-land degradation. Removal of the rangeland vegetation cover takes place both by overgrazing of forage and by transforming rangelands to cultivated systems worldwide. Removal of vegetation cover when combined with unsustainable soil and water management practices in the converted rangelands brings about soil erosion, soil structure change, and soil fertility decline.

1.3. Coping with desertification

Measurement of persistent reduction in the capacity of eco-systems to supply services provides a robust and operational way to quantify land degradation and desertification. Productivity may therefore be measured in terms of the “things that ecosystems provide that matter to people”—that is, ecosystem services.

The coping capacity of the affected population and the resilience of the ecosystem on which it depends determine the duration beyond which impaired services cause irreversible consequences. Dryland people have found ways of coping with periods of scarcity lasting up to several years. However, periods significantly longer than this can overwhelm their resources and adaptation strategies. Their capacity to cope with a shortage of services for extended periods can be increased by many factors, including demographic, economic, and policy factors (such as the ability to migrate to unaffected areas) and the time that has elapsed since the last stress period.

Policies leading to unsustainable resource use and lack of supportive infrastructure are

major contributors to land degradation. Agriculture can play either a positive or a negative role, depending on how it is managed. This in turn depends on the socioeconomic resources available, the policies adopted, and the quality of governance.

Irrigation has led to increased cultivation and food production in drylands, but in many cases this has been unsustainable without extensive public capital investment. Large-scale irrigation has also resulted in many environmental problems—such as water-logging and salinisation, water pollution, eutrophication, and unsustainable exploitation of groundwater aquifers—that degrade the drylands' service provisioning. In such irrigation approaches, rivers are often disconnected from their floodplains and other inland water habitats, and groundwater recharge has been reduced. These human-induced changes have in turn had an impact on the migratory patterns of fish species and the species composition of riparian habitat, opened up paths for exotic species, changed coastal ecosystems, and contributed to an overall loss of freshwater biodiversity and inland fishery resources. On the whole, there is a decline in biodiversity and services provided by inland water systems in drylands, which further exacerbates desertification.

Integrated land and water management are key methods of desertification prevention. All measures that protect soils from erosion, salinisation, and other forms of soil degradation effectively prevent desertification. Sustainable land use can address human activities such as overgrazing, overexploitation of plants, trampling of soils, and unsustainable irrigation practices that exacerbate dryland vulnerability. Management strategies include measures to spread the pressures of human activities, such as transhumance (rotational use) of rangelands and well sites, stocking rates matched to the carrying capacity of ecosystems, and diverse species composition. Improved water management practices can enhance water-related services. These may include use of traditional water-harvesting techniques, water storage, and diverse soil and water conservation measures. Maintaining management practices for water capture during intensive rainfall episodes also helps prevent surface runoff that carries away the thin, fertile, moisture-holding topsoil. Improving groundwater recharge through soil-water conservation, upstream re-vegetation, and floodwater spreading can provide reserves of water for use during drought periods.

In the dry subhumid and semiarid zones, conditions equally favour pastoral and cropping land use. Rather than competitively excluding each other, a tighter cultural and economic integration between the two livelihoods can prevent desertification. Mixed farming practices in these zones, whereby a single farm household combines livestock rearing and cropping, allows a more efficient recycling of nutrients within the agricultural system. Such interactions can lower livestock pressure on rangelands through fodder cultivation and the provision of stubble to supplement livestock feed during forage scarcity (and immediately after, to allow plant regeneration) due to within- and between-years climatic variability. At the same time, farmland benefits from manure provided by livestock kept on fields at night during the dry season.

Desertification can be avoided by turning to alternative livelihoods that do not depend on traditional land uses, are less demanding on local land and natural resource use, yet provide sustainable income. Such livelihoods include dryland aquaculture for production

of fish, crustaceans and industrial compounds produced by microalgae, greenhouse agriculture, and tourism-related activities. They generate relatively high income per land and water unit in some places. Dryland aquaculture under plastic cover, for example, minimizes evaporative losses, and provides the opportunity to use saline or brackish water productively. Alternative livelihoods often even provide their practitioners a competitive edge over those outside the drylands, since they harness dryland features such as solar radiation, winter relative warmth, brackish geothermal water, and sparsely populated pristine areas that are often more abundant than in non-drylands. Implementation of such practices in drylands requires institution building, access to markets, technology transfer, capital investment, and reorientation of farmers and pastoralists.

Desertification can also be avoided by creating economic opportunities in drylands urban centres and areas outside drylands. Changes in overall economic and institutional settings that create new opportunities for people to earn a living could help relieve current pressures underlying the desertification processes. Urban growth, when undertaken with adequate planning and provision of services, infrastructure, and facilities, can be a major factor in relieving pressures that cause desertification in drylands.

Effective restoration and rehabilitation of desertified drylands require a combination of policies and technologies and the close involvement of local communities. Examples of measures to restore and rehabilitate include establishment of seed banks, restocking of soil organic matter and organisms that promote higher plant establishment and growth, and reintroduction of selected species; investing in land through practices such as terracing and other counter-erosion measures, control of invasive species, chemical and organic nutrient replenishment, and reforestation.

For desertified areas, rehabilitation strategies have a mix of positive and negative impacts on ecosystems, human well-being, and poverty reduction. The success of rehabilitation practices depends on the availability of human resources, capital for operation and maintenance, infrastructure development, the degree of dependence on external sources of technology, and cultural perceptions. Adequate access to these resources, combined with due consideration of the needs of local communities, can lead to successful rehabilitation of some ecosystem services and hence reduce poverty. Some success stories have been observed; for example, farmers in the Machakos (Kenya) restored degraded lands. This was achieved through access to markets, off-farm income, and technologies that increased land and labour productivity faster than population growth.

1.4. Prevention or reversal of desertification

Integrated land and water management are key methods of desertification prevention. All measures that protect soils from erosion, salinisation, and other forms of soil degradation effectively prevent desertification. Sustainable land use can address human activities such as overgrazing, overexploitation of plants, trampling of soils, and unsustainable irrigation practices that exacerbate dryland vulnerability. Management strategies include measures to spread the pressures of human activities, such as transhumance (rotational use) of rangelands and well sites, stocking rates matched to the carrying capacity of ecosystems, and diverse

species composition. Improved water management practices can enhance water-related services. These may include use of traditional water-harvesting techniques, water storage, and diverse soil and water conservation measures. Maintaining management practices for water capture during intensive rainfall episodes also helps prevent surface runoff that carries away the thin, fertile, moisture-holding topsoil. Improving groundwater recharge through soil-water conservation, upstream re-vegetation, and floodwater spreading can provide reserves of water for use during drought periods.

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Desertification can be avoided by turning to alternative livelihoods that do not depend on traditional land uses, are less demanding on local land and natural resource use, yet provide sustainable income. Such livelihoods include dryland aquaculture for production of fish, crustaceans and industrial compounds produced by microalgae, greenhouse agriculture, and tourism-related activities. They generate relatively high income per land and water unit in some places. Dryland aquaculture under plastic cover, for example, minimizes evaporative losses, and provides the opportunity to use saline or brackish water productively. Alternative livelihoods often even provide their practitioners a competitive edge over those outside the drylands, since they harness dryland features such as solar radiation, winter relative warmth, brackish geothermal water, and sparsely populated pristine areas that are often more abundant than in non-drylands. Implementation of such practices in drylands requires institution building, access to markets, technology transfer, capital investment, and reorientation of farmers and pastoralists.

Desertification can also be avoided by creating economic opportunities in drylands urban centres and areas outside drylands. Changes in overall economic and institutional settings that create new opportunities for people to earn a living could help relieve current pressures underlying the desertification processes. Urban growth, when undertaken with adequate planning and provision of services, infrastructure, and facilities, can be a major factor in relieving pressures that cause desertification in drylands. This view is relevant when considering the projected growth of the urban fraction in drylands, which will increase to around 52% by 2010 and to 60% by 2030.

Effective restoration and rehabilitation of desertified drylands require a combination of policies and technologies and the close involvement of local communities. Examples of measures to restore and rehabilitate include establishment of seed banks, restocking

of soil organic matter and organisms that promote higher plant establishment and growth, and reintroduction of selected species. Other rehabilitation practices include investing in land hrough practices such as terracing and other counter-erosion measures (Figure 4), control of invasive species, chemical and organic nutrient replenishment, and reforestation. Policies that create incentives for rehabilitation include



FIGURE 4: Earth dam, fight against erosion (Djibouti)

capacity building, capital investment, and supportive institutions. Community involvement in conceptualization, design, and implementation is essential for rehabilitation approaches.

2. BACKGROUND INFORMATION ON CLIMATE CHANGE

Climate change refers to significant long-term modification (or variation) of the climate, due mainly to human activities. The most widely used indicator for characterising climate change at present is the increase in concentrations of greenhouse gases (GHG) related to human activity. These emissions are the main cause of the increase in mean global temperature, from 0.3° to 0.6 °C over the last 100 years (IPCC, 2001). The most recent report of the IPCC (2007) is even more alarming as it states that the mean increase in temperature over the last 100 years has grown from 0.6 °C in 2001 to 0.74 °C in 2007⁴.

The concentration of greenhouse gases is a result of industrial activity in the mainly industrialised countries; African countries, which are not heavily industrialised, contribute to this in only a slight way.

In the recent years Climate Change has become a social, economic and environmental challenge facing humankind both at local and global level. The fourth report of the Intergovernmental Panel on Climate Change has revealed that climate change is real and already happening. While it is difficult to precisely predict the consequences of Climate Change, enough understanding is available on the kind of risks posed.

The impacts include melting of glaciers, floods, frequent prolonged droughts, reduced water supply, decline in crop yields to food insecurity, the increase in pests and diseases

⁴. Sahara and Sahel Observatory (OSS), 2007 “Climate change adaptation and fight against desertification”, 2007.

for livestock, wildlife and crops, increase in invasive species, increase of vector-borne diseases including malaria and Rift Valley fever, water-borne diseases including dysentery, bilharzias, cholera and typhoid, declining levels of fresh water bodies, rising sea levels leading to displacement of people and disruption of both terrestrial and marine ecosystems and important natural habitats, which are now not only predicted but vividly observed in many parts of the world. The recurrence of extreme weather events occur with increasing intensity and frequency.

However, the impacts are not evenly distributed, with the poorest countries being most vulnerable. This is because the economies of these countries are generally dependent on climate-sensitive natural resources and thus less able to cope with the negative impacts of climate change⁵.

Drought and desertification is a serious environmental threat in nearly all the countries of the IGAD Sub Region; the characteristics of drought and desertification include:

- Highly variable and irregular rainfalls.
- Reducing crop and pasture yields.
- Increasing loss of vegetation cover.
- Increased evapotranspiration.
- Higher inter-annual variations of rainfall volumes, durations and extreme events.
- Shorter and more intense wet seasons and longer and drier dry seasons leading to crop and pasture failures.

The effects of drought and desertification include⁶:

- An increase in demand for irrigation water with the risk of conflicts between farmers over water rights;
- A growth in demand for fertilisers with increased risks of groundwater pollution;
- Lack of treatment for grey water;
- Water shortages resulting from the exhaustion, or pollution, of groundwater;
- Increased pressure on aquifers and the risks of transnational conflicts over water rights.

So severe is the issue of desertification in the sub region that some organisations such as the United Nations Convention to Combat Desertification are proposing to address it as a human rights issue⁷.

It is estimated that 50% of the estimated 854 million hungry people live in marginal, dry and degraded lands. Half of the world's hungry people depend for their survival on lands which are inherently poor and which may be becoming less fertile and less productive as a result of the impacts of repeated droughts, climate change and unsustainable land use.

⁵ East African Community Climate Change Policy, EAC Secretariat, May 2010 obtained from the EAC Website.

⁶ OSS ibid

⁷ UNCCD: Human Rights and Desertification, Exploring the Complimentarity of International Human Rights Law and the United Nations Convention to Combat Desertification, Issue Paper 1. 2008.

Land degradation also causes migration and intensifies conflict over resources, particularly between pastoral and farming communities⁸.

Traditional international environmental law protects the environment by regulating the rights and obligations of nation-states and the conflicts between them; it is not designed to protect people. On the other hand, traditional human rights law regulates the relationship between governments and their citizens, and offers universal guarantees that protect the right to life, as well as the right to an adequate standard of living, which includes the rights to food and water⁹.

3. BACKGROUND INFORMATION ON WETLANDS

According to the Ramsar Convention, ‘wetlands include a wide variety of habitats such as marshes, peat lands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs’¹⁰.

The Ramsar Convention recognises the difficulty of developing wetland policies for the Contracting Parties. With Eritrea, Ethiopia and Somalia not being members of the Convention, it is difficult to assess whether their current policies are in conformity with the requirements of the Convention.

In the transboundary context, most of the boundaries between the IGAD states follow natural river courses (wetlands) even in the dry arid areas such as between Kenya, Ethiopia and Somalia or between Somalia and Djibouti. Wetlands ecosystems are therefore important contributors to the transboundary environmental frameworks in the IGAD region.

The Ramsar Secretariat has prepared a number of Handbooks to guide the member states of the Convention on the wise use of wetlands. Key among the messages given therein are:

- Establishment of the policy, legal and institutional framework for wetland identification, gazetting, protection and regulation of use (wise use).
- Communications, education and public awareness (CEPA).
- Impart of public participation skills in the community.
- Guidance on the management of river basins etc.

Large parts of Uganda are wetlands; however, Kenya, Somalia, Djibouti, Eritrea and Sudan have coastlines with the oceans or the Red Sea and therefore have wetlands along their shores. The internal lakes in the IGAD region are numerous including transboundary salt lakes such as Lake Turkana on Kenya – Ethiopia border; Lake Abbe on the Ethiopia Djibouti border.

⁸ Ibid, page 7.

⁹ Ibid, page 13.

¹⁰ Ramsar Convention Secretariat, 2007. Wise use of wetlands: A Conceptual Framework for the wise use of wetlands. Ramsar handbooks for the wise use of wetlands, 3rd edition, vol. 1. Ramsar Convention Secretariat, Gland, Switzerland.

THE IMPACT OF DROUGHT AND DESERTIFICATION ON DJIBOUTI

1. INTRODUCTION

Desertification is recognized as a very severe problem in Djibouti. It is reported that the modest forest cover in Djibouti is being degraded for wood for heating and cooking and coal production. This coupled with nomadic practices by a large part of the population, increases the vulnerability of the country to desertification¹¹.



FIGURE 5: Harvesting salt from Lake Asal, Djibouti.

Djibouti is described as being a stony semi-desert country. The water sources are mostly salty – such as Lake Abbe, Lake Asal (Figure 5). Harvesting of salt from the numerous salt lakes is a major source of income for the country's peasants.

¹¹. Government of the Republic of Djibouti, 'Final Environment Report' prepared for the OSS.

2. EFFECTS ON NOMADIC PASTORALISM

Drought, desertification and climate variability affect the mainly nomadic herders that dominate the countryside, leading fragile economic existence. The cattle economy accounts for approx 5% of GDP yet 30 – 50% of the population is engaged in livestock industry. Djibouti has suffered severe repeated droughts in the recent past, leading to rapid urbanisation as the former pastoralists abandon the practice and seek urban livelihoods in the urban centres.

Livestock producers face additional constraints as well, including:

- extremely harsh, arid climatic and environmental conditions, with particularly severe persistent drought for the past five years causing loss of fodder and animal life, which in turn has led to the breakdown of traditional land and environmental management strategies and rapid urban migration.
- very low infrastructure levels, such as tarred roads, animal handling points, wells and water retention mechanisms, livestock markets and electricity access.
- exceedingly low human and organizational capacity, with only 27% adult literacy and a dearth of adequate resources and training opportunities within government agencies.
- lack of access to markets, credit or other forms of employment.

Other constraints include:

- Competition from animal producers living primarily in Ethiopia and Somalia, where animals are better fed and input costs are lower.
- Insufficient access to animal health care and pharmaceuticals, with only two public and several private veterinarians in the entire country.
- Inadequate sanitation and hygiene regulations and protocols, both for internal markets and abattoirs, and for export facilities.
- Repeated or persistent bans on livestock exports and/or inequitable access to export markets.
- Lack of donor coordination on local and international livestock development efforts¹².

Djibouti derives most of its revenue from renting its port and from French and USA military bases, leading to a high level of foreign currency that distorts the purchasing power of the peasants. Industrialization is very low as is arable agriculture.

Djiboutians working in the primary sector are in general extremely vulnerable to inhospitable climatic conditions. Soils are exceedingly poor except for about 10% of the land. Djibouti is also subject to intense flooding during the infrequent rains. Very little water is absorbed, and fast moving rivers quickly develop, turning dry river beds into dangerous flows towards the sea. While some retaining walls have been built to slow the water's escape, most are simple earth mounds in poor condition. To make matters worse, extremely hot, violent winds tear through the country during the heat of summer, when average temperatures

¹² The Political Economy of Livestock Policy, the Case of Djibouti by Jennifer N. Bras. IGAD Livestock Policy Initiative, 2007.

reach well into the 40s and 50s.

While many of these conditions have always existed, recurring or persistent drought during the past decade has combined with over-grazing of pastoral lands to progressively worsen living conditions. Several droughts have wiped out entire herds of some pastoralists. Currently, 150,000 people are considered at risk, suffering extreme loss of livestock – in some districts as many as 80% of animals have died, and the morbidity rate of surviving animals remains very high.

Livestock are reared in three manners in Djibouti: extensive nomadic pastoralism, semi-extensive (semi-sedentary/semi-nomadic), and intensive (sedentary). Extensive production is the most common type – until very recently, 90% of Djibouti’s pastoralists raised their animals in this manner. These nomads “don’t know borders: borders are irrelevant to them” as they travel with their herds throughout Djibouti, Eastern Ethiopia and Northern Somalia, covering 100-300 km in transhumance. Thus the Djiboutian production system is intimately tied with that of neighbouring countries, where Djiboutian herders spend much of the year, as climatic and pasture conditions are better. The implication is that it is often impossible to determine an animal’s true origin. Second, semi-extensive production has been rapidly developed in the past three decades, with about half of Djibouti’s herders now semi-sedentarised around water points and villages. These pastoralists still roam considerably, approximately 20-100 km, but they return to a base camp, where they often leave their families to tend a small garden and attend school. The semi-sedentarisation of pastoralists has been a policy of the government since before independence, as it believes this allows people access to social services, particularly education and health. Gardening, where there is adequate water, also increases their food security.

3. MARKETING MILK

For the majority of poor livestock producers, milk and derivative products like butter comprise an important part of diet and livelihood. At present, most animals are milked only for subsistence purposes, as access to market is a near impossibility for most Djiboutians. Pastoralists are constrained by lack of demand at the local level, since nearly all rural dwellers have their own milking animals. This means the only sizable market is in the capital, where two-thirds of the population lives. Demand for fresh milk is extremely high in the city, since most residents only recently abandoned their nomadic tradition, in which they drank milk daily.

Despite the demand, however, most urbanites consume inferior-tasting powdered or long-life milk, approximately 1.5 million kg of which is imported each year. In fact, only 10% of demand is met through peri-urban production. Rural pastoralists have not been able to fill the gap owing to: a) the absence and expense of refrigeration facilities, b) insufficient regulation of hygiene, quality control and pasteurization, c) lack of marketing, collection and distribution organizations, d) limited livestock extension services, and e) the costliness in time and money of transportation, as only 10% of Djibouti’s roads are paved. As a result, only pastoralists along major roads, particularly the Djibouti-Ethiopian trucking route, are able to sell their milk. Even then, considerable quantities of milk are wasted, as there is no means to preserve what isn’t sold.

4. STRATEGIES THAT MAY BE ADOPTED TO COMBAT DROUGHT AND DESERTIFICATION IN DJIBOUTI

- Improved agricultural capacity building since the agricultural methods and know-how are lacking for the predominantly pastoral communities. Djibouti is not traditionally a sedentary agriculture country and technical knowhow is limited to expatriates and a few locals. Training of trainers (extension workers) is critical in order to build a mass of workers to train the pastoralists.
- Improved inputs such as seeds to plant high energy grass that increases the food supply for the milk producing animals. This is implemented to allow the pastoralists to acquire and retain plots of land where they can practice semi-sedentary pastoralism, where the milk cattle are given special high energy grass planted around the oases. Without semi-sedentary arrangement, it is impossible to improve the grass quality since the pastoralists are often on the move.
- Providing the market for the animal products from the remote areas of Djibouti such as milk, meat and hides and skins. Currently because of the poor road infrastructure and shortage of processing capacity for the animal products, much of the products are sold for prices lower than their market value. Saudi Arabia has an agreement to accept animal products from Djibouti but the processing of the products for export is poor. With improved incomes, the pastoralists will reduce transhumance and settle down where the government can support them with veterinary services and education.

THE IMPACT OF DROUGHT AND DESERTIFICATION ON KENYA

1. INTRODUCTION

Over 80% of Kenya is characterised as arid and semi-arid and therefore prone to drought and desertification¹³.

In Kenya adverse effects of climate change have been experienced including variations in weather patterns and global warming as a result of recent industrial developments. Other severe events related to climate change include prolonged and frequent droughts, floods, resurgence of disease pests and environmental disasters. The disappearing glaciers on Mt Kenya have served as evidence of global warming and melting glacier. It is estimated that the mountain has lost about 92% of her ice through melting in the past 100 years^{14, 15}.

Variability in weather patterns have been observed in Kenya leading to severe prolonged and frequent droughts commonly called La Niña stretching over wider areas in the country since the 1970s. For instance the La Niña of 1999-2001 was the longest and severest drought since early 1950s which caused devastating effects especially human livelihoods and loss of livestock recurred in January-March 2006. The drought affected about 4 million people due to damage on crops as well as reduced yields. Droughts have caused starvation, loss of life and massive land degradation. Severe flooding has also been experienced in Kenya commonly referred to as El Niño. The severe flooding experienced over the period 1997/8 constitutes one of the worst flooding to be experienced in the country in recent years.

2. NATIONAL CLIMATE CHANGE RESPONSE STRATEGY

Currently, two funds have been created under the UNFCCC to tackle adaptation to climate change. The **Least Developed Countries Fund (LDCF)** created under Article 4.9 of the UNFCCC supports the preparation of National Adaptation Programmes of Action (NAPAs) in countries classified as LDCs by the United Nations Development Programme (UNDP). The NAPAs help LDCs *identify priority activities that respond to their urgent and immediate needs to adapt to climate change – those for whose further delay would increase vulnerability and/or costs*

¹³. Government of Kenya, 'Final Environment Report', one of the reports prepared under the OSS.

¹⁴. NEMA Kenya, 'State of the Environment, Kenya, 2007'.

¹⁵. Government of Kenya, 'National Climate Change Response Strategy (Executive Brief)', April 2010, accessed from <http://www.environment.go.ke/images/complete%20nccrs%20executive%20brief.pdf> on 11.08.2010.

at a later stage. Implementation of priority actions identified in NAPAs has only recently begun in select LDCs, with about 26 projects having been approved for funding.

Kenya is not an LDC and therefore does not qualify for the LDCF. The **Special Climate Change Fund** (SCCF) is the other UNFCCC fund through which adaptation programmes and projects can be financed. This fund was established in 2001 under decision 7 of COP7 (Decision 7/CP.7) to finance projects relating to adaptation, technology transfer and capacity building, energy, transport, industry, agriculture, forestry, waste management, and economic diversification in non-Annex 1 countries. The Fund is not dedicated to adaptation activities, although adaptation remains the key priority. Kenya’s project on *Adaptation to Climate Change in Arid Lands* funded by the World Bank is one of the first SCCF projects. Also in the pipeline for Kenya is the *Adaptation to Climate Change and Health* project to be funded by SCCF and channelled through the World Health Organization (WHO) and UNDP¹⁶.

3. EVIDENCE OF CLIMATE CHANGE IN KENYA

Region	Trend	Magnitude (°C) Min. temp.	Magnitude (°C) Max. temp.
Western	Increase	0.8-2.9	0.5-2.1
Northern & North-eastern	Increase	0.7-1.8	0.1-1.3
Central	Increase	0.8-2.0	0.1-0.7
South Eastern districts	Increase	0.7-1.0	0.2-0.6
Coastal strip	Decrease in min, increase in max. temp.	0.3-1.0	0.2-2.0

Government of Kenya,
‘National Climate Change
Response Strategy’, 2010.

TABLE I. Trend of temperature rise in Kenya over the from the 1960s

3.1. Temperature rise

An analysis of both minimum (T_{min}) and maximum temperatures (T_{max}) based on the standard seasons of December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON) reveals that the rise in temperatures over the northern parts of the country is relatively higher than in other parts especially from October to February period. Similarly, the decrease in minimum temperatures in the northern parts of the coastal strip is also relatively higher than in the southern parts of the coastal areas during the same period. Lamu in the north coast shows a drop of 1 °C from a mean of 24.5 °C in the early 1960s to 23.5 °C in the recent ten years, whereas Mombasa in the south coast indicates a drop of about 0.3 °C from 23 °C in the early 1960s to 22.7 °C in the recent ten years.

From the early 1960s, Kenya has experienced generally increasing temperature trends over vast areas. Over the inland areas, the trends in both minimum (night/early morning) and maximum (daytime) temperatures depict a **general warming** (increasing) trend with time. However, the increase in the minimum temperatures is steeper than in maximum

¹⁶. Government of Kenya, ‘National Climate Change Response Strategy’, 2010.

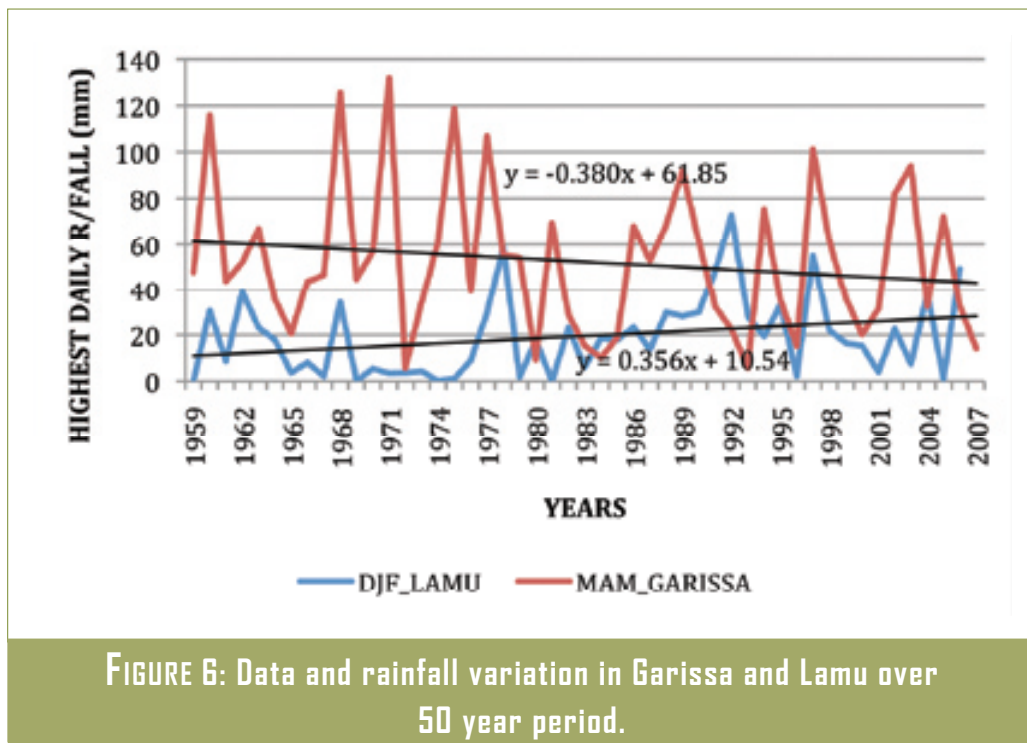
temperatures. The result of the steeper increase in T_{\min} and a less steep increase T_{\max} is a reduction in the diurnal temperature range (difference between the maximum and minimum temperatures).

3.2. Rainfall patterns

Daily and monthly rainfall records are used to determine trends that have characterized rainfall in Kenya since the early 1960s. The time series of annual and seasonal rainfall for the standard seasons of December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON) indicate that:

- Neutral to slightly decreasing trends are manifested in the annual rainfall series over most areas. This is mainly due to an associated general decline with time of rainfall in the main rainfall season of March-May (the ‘Long Rains’) over most areas.
- There is a general positive trend (increase) in rainfall events of September to February period suggesting a tendency for the ‘Short Rains’ (October-December) season to be extending into what is normally hot and dry period of January and February over most areas. This may be attributed to possibly more frequent occurrences of El-Niño events occasionally coupled with relatively warmer sea surface temperatures over the western Indian Ocean (along the coast of east Africa) and relatively cooler than average sea surface temperatures (SSTs) to the east of the Indian Ocean.

This sea surface temperature pattern is conducive for enhancing rainfall over the country. Even in the absence of El-Niño conditions, this pattern over the Indian Ocean results into heavy rainfall during the ‘Short Rains’ season as was the case in 1961-62 and the recent 2006-07 rainfall events.



Government of Kenya, 'National Climate Change Response Strategy', 2010.

The highest rainfall events recorded every year and in each of the four standard seasons of December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON) were subjected to time series analysis to derive the trend patterns that they depict.

In general, annual highest rainfall events indicate the 24-hour intense rainfall amounts observed in the recent years are relatively lower than those in the early 1960s. Effectively, these values have been reducing (negative trend) with time. These trends are also depicted in the time series of the 'Long Rains' (MAM) season that contributes a significant amount of rainfall to the annual totals over most parts of the country. However, the changes (reductions) are not very significant.

Most of the standard seasons also depict the same type of patterns in the highest daily rainfall values observed. There is an indication of relatively more intense rainfall occurring more frequently over the coastal strip and the northern parts of the country in the SON and DJF seasons.

4. IMPACTS ON NATURAL SYSTEMS

4.1. Forestry sector

Kenya has a landmass of about 582,350 km² with only 17% of arable land while 83% consists of arid and semi-arid land (ASAL). There are indications that the ASAL is increasing.

Kenya's natural resources, particularly its rich flora and fauna are among the country's most valuable natural assets. Unfortunately, climate change now threatens to eradicate this rich biodiversity.

In the forestry sector, climate change will firstly affect the growth, composition and regeneration capacity of forests resulting in reduced biodiversity and capacity to deliver important forest goods and services. This will then cause desertification, deforestation and forest as well as land degradation as communities strive to derive their livelihoods on declining forest resources. This is already evident in many places including upper parts of Eastern Province like Machakos and Kitui, and Taita Taveta in Coast Province as well as all ASALs of Kenya. Invasive species such as *Prosopis juliflora* ('mathenge') have been witnessed¹⁷.

4.2. Rangelands

Kenya's rangelands, which support millions of pastoralists and small-scale agro-pastoralists, mainly occur in areas where rainfall is low and erratic and soils are highly variable and infertile. Therefore the rangelands are unsuitable for production of crops that are not drought tolerant. The rangelands are characterised by a number of habitat structures ranging from open grasslands to closed woody and/or bushy vegetation with varying amounts and composition of grass cover and species.

¹⁷ Government of Kenya, 'National Climate Change Response Strategy', 2010.

The impacts of climate change on Kenya's rangelands include:

- Change in pasture productivity as has been observed in the North Eastern Province where extremely strong winds and flash floods erode and wash away grass seeds. Consequently, the growth of grass is inhibited even during good rainfalls. Loss of wildlife habitats emerge as a secondary impact of these factors,
- Carbon dioxide fertilization, which leads to higher plant productivity, particularly the proliferation of invasive species,
- Disruption of natural ecosystems and subsequent change in species' ecological range, altering predator-prey interactions, decoupling animals from food sources and/or reducing habitat span, and
- Droughts that affect grasslands causing massive livestock and wildlife deaths and an increase in human-human and wildlife-human conflicts. Cases of conflict have been reported in areas around the Lower Tana Delta, Laikipia, and Lagdera. As an example, in the Lagdera case (2005) warthogs attacked and killed goats and sheep to drink their intestinal fluids after the warthog's natural watering points dried up.

4.3. Impact on livestock

- The strong winds and dust storms in most parts of Northern Kenya during the droughts of 2006 to 2009 contributed to the reduction of forage availability as they swept away top soil together with grass seeds, thus making grass regeneration impossible even when it rains. This worsened the desertification trends in the areas.
- Outbreaks of diseases like the Rift Valley Fever (RVF) have been linked to climate change. The outbreak of RVF is known to occur during periods of high humidity that follow abnormally long rains. Kenya is facing a ban on the export of meat to the European Union (EU) market until 2010 because of the failure to control RVF as well as foot and mouth disease.

4.4. Impact on horticulture

- Much of horticultural practice in Kenya is carried out in ASALs, making the sector highly susceptible to the impacts of climate variability and change. The recent adverse weather has seen a decline in fresh vegetable production in Laikipia, Kieni, Kibwezi, Machakos and Mtito Andei.
- Climate change has profound effects on populations of crop pests (e.g. insects, mites, slugs), affecting their development, reproduction and dispersal. The rate at which most pests develop depends on temperature and every species has a particular 'threshold temperature' above which development can occur, and below which development ceases.

4.5. Coastal and marine ecosystems

The Kenyan coastline is characterised by a rich diversity of flora and fauna including fish, coral reefs and mangrove forests. Kenyan coral reefs are well distributed around most of the oceanic islands. They buffer the coastline against the impacts of waves and the full force

of storms and cyclones. With all its benefits, the Kenyan coastline is extremely vulnerable to sea level rise. The most vulnerable aspects of the coastline are developments in low-lying areas which consist of agriculture, infrastructure and both tourist facilities and hotspots.

The impacts of climate change on the Kenya's marine ecosystems include:

- Potential submergence of Mombasa with even a rise of 0.3 m in the average sea level. Rising sea levels will lead to the inundation and displacement of coastal wetlands, the erosion of shorelines, increased salinity and the intrusion of saline water into coastal aquifers. Saltwater intrusion into ground water resources and salt wedge estuaries are phenomena that have been observed already in some places such as Lamu.
- Coral reef bleaching is a common stress response of corals to many of natural and anthropogenic disturbances. Beginning in the 1980s, the frequency and widespread distribution of reported coral reef bleaching events increased. This has been attributed to global warming and consequent rising seawater temperatures.
- Predicted effects of climate change on mangroves include both more extreme droughts and flooding. In 1997, 1998 and 2006, massive sedimentation due to erosion of terrigenous sediments following extremely heavy rainfall caused mangrove dieback in many areas along the Kenyan coast.

4.6. Impacts on water resources

- With its natural endowment of renewable freshwater of only 21 billion cubic meters (BCM) which amounts to 647 cubic meters (m³) per capita per annum under normal circumstances, Kenya is classified as a water-scarce country. The country's water resources are unevenly distributed in both time and space in five drainage basins namely Lake Victoria, Rift Valley, Athi River, Tana River and Ewaso Ng'iro. Climate change will worsen this already precarious situation as it affects precipitation, thus further altering the spatial and temporal availability of water resources.
- According to the National Environmental Management Authority's (NEMA) State of Environment Report of 2006/2007, major floods periodically afflict Lake Victoria basin, the Lower Tana basin and the coastal region – occurring at least six times in the past 50 years. In these areas, higher turbidity, siltation, and sedimentation occur. Floods carry fertiliser and pesticide residues into water bodies resulting in eutrophication, which has detrimental impacts on water quality and aquatic life. Until recently, such episodes were assumed to represent natural climate variability but now scientific evidence points to climate change as the driving force behind the frequency and intensity of these events. Serious droughts have occurred at least 12 times in the past 50 years. Major rivers including the Tana, Athi, Sondu Miriu, Ewaso N'giro and Mara have experienced severe reduced volumes during droughts and many seasonal ones have completely dried up. The parts of the country most affected are the Eastern, North Eastern and parts of the Rift Valley provinces.
- According to the same report, serious droughts have occurred at least 12 times in the past 50 years. Major rivers including the Tana, Athi, Sondu Miriu, Ewaso Ng'iro and Mara have experienced severe reduced volumes during droughts and many seasonal ones have completely dried up. The parts of the country most affected are the Eastern, North Eastern

and parts of the Rift Valley provinces. These impacts are attributed to climate change.

4.7. Impact on agriculture and food security

■ Climate change affects the four components of food security - food availability, food accessibility, food utilization and food system stability - in various direct and indirect ways. As a result of climate change, there is increased frequency and intensity of extreme weather events like droughts and floods, which lead to losses of productive assets, personal possessions and even life. The country's famine cycles have reduced from 20 years (1964-1984), to 12 years (1984-1996), to two years (2004-2006) and to yearly (2007/2008/2009), necessitating the Government's distribution of 528,000 metric tonnes (MT) of assorted foodstuffs worth Ksh. 20 billion over the last five years alone to feed a population between 3.5 million and 4.5 million people annually.

■ Kenya has had successive seasons of crop failure, increasing the country's food insecurity. The 1999/2000 La Niña droughts resulted in 4.7 million Kenyans facing starvation, while the effects of the 2006-2009 successive drought episodes were worse with unofficial reports indicating nearly 10 million Kenyans faced starvation during the worst episode in 2009. The decline in agricultural productivity is attributed to variation in the diurnal temperature range, which has profound effects on agricultural production systems because crops have specific range of temperatures within which they grow optimally.

4.8. Impact on tourism

■ Frequent and severe droughts have hit the country since the 1990s, reducing forage in rangelands, as well as drying up and tremendously reducing the volume of rivers, which consequently affects wildlife – a resource the Kenyan tourism industry depends upon. Cases of wildlife deaths have increased in the recent past with the Kenya Wildlife Service reporting the death of 14 elephants in 2007, 28 in 2008 and 37 in 2009 due to 'extraordinary and prolonged dry seasons.' Lately, the reduction in the volume of the Mara River due to climatic variations and the destruction of the Mau catchment has had a toll on one of the wonders of the natural world – the spectacular migration of hundreds of wildebeests across the Mara River as they migrate between the Serengeti National Park in Tanzania and the Maasai Mara Reserve in Kenya.

■ Global warming is likely to disrupt and even destroy some of the tourist sites such as the snow-caps of Mt. Kenya, the coastal rainforests, fragile marine ecosystems and the marine parks. 'Coral bleaching' of the Kenyan coral reef has been observed.

4.9. Impact on forest products

■ The ASALs are subject to recurring droughts, which when coupled with overexploitation of resources, result in high vulnerability to land degradation and desertification. This not only increases levels of GHG emissions, but simultaneously threatens livelihoods.

■ With rainfall as one of the most affected climatic elements, the survival of Kenya's forest resources is likely to be severely affected. The vulnerability of Kenya's forest resource is further exacerbated by the depletion of forest and land cover through rapid increase

in population and demand for human settlements, both agricultural and grazing land, construction materials, food, fuel wood, essential oils and herbal medicines. Climate change only adds to the stresses on Kenya's forest cover.

4.10. Impact on fisheries

- There is strong evidence partly linking ENSO events with systematic changes in plankton abundance and aquatic/marine plant as well as animal composition over recent decades in many regions worldwide. The ENSO events with phases of warm water reduce plankton production, and cause fish stocks to decline. Heavy tropical storms and sea level rise that are projected with the changing climate will make fishing a dangerous activity.
- Fluctuation of river volumes and to some extent lake levels, alters breeding ecology not only of permanent populations but also of anadromous fishes. Such fluctuations also have a deleterious consequence on the overall fish production in the country. Climate change is predicted to alter hydrological regimes, which in turn will influence biological, biogeochemical and hydrological functions of wetlands.
- Fishing in major lakes such as Victoria and Turkana is likely to be affected by recurrent droughts and rising temperatures, conditions that starve the lakes of inflowing water and evaporate more of the water they have, leading to reductions in water levels. Coupled with improper practices such as overfishing, these reductions in water levels will lead to tremendous reductions in fish stocks.

4.11. Other impacts of climate change

- Climate change may create more floods and lead to rise in the coastal sea levels that may lead to inundation and damage to the coastal roads.
- Floods in the ASALs have led to damage or destruction of road bridges, thus cutting off vital food and agricultural supplies to large parts of northern Kenya.
- Damage to telephone network by storms, poor radio and TV signals and delay in the delivery of mails during storm events. Flooding and high temperatures may affect terrestrial and sea based communications such as mobile telephone networks and undersea cables.
- Climate change affects all areas of the electricity sector, from generation through to distribution and consumption. Kenya's electricity supply largely depends on hydro sources, which account for over half of the total effective capacity (1332.2 MW). Geothermal sources of electricity account for 12.2% and the remaining 29.7% is predominantly petroleum based thermal generation. Hydropower potential has dramatically reduced in the past 20 years due to the destruction of water catchment areas. Hydroelectric power generation is also affected by soil erosion and the consequent siltation of dams.
- Climatic catastrophes such as high wind, heavy rainfall, heat and cold can result in a wide range of scenarios such as tropical storms, floods, landslides, droughts and sea-level rise which displace populations and cause deaths, which in turn can lead to conflicts and civil unrest. Landslides and mudslides caused by heavy storms have in the past claimed many lives especially in the Kenya highlands. Population displacement and migration from climate disaster-prone areas (e.g. drought prone northern Kenya and sea-level rise in the

coastal region) are expected to increase. This in turn leads to rapid urban growth with its attendant problems.

■ Kenya's health sector is vulnerable to climate change in three ways: (i) the increase in vector-borne diseases such as malaria and RVF (ii) mortality due to climate-related disasters; and (iii) overstretching of the health infrastructure. Due to these vulnerabilities, the country will likely be required to spend more on the health sector. Environmental diseases such as typhoid, amoeba, cholera, and bilharzias, normally associated with contaminated water and poor sanitation, reach epidemic levels in areas where water and sanitation facilities are inadequate or are in poor state. Climate change may worsen the condition of sanitation systems.

5. STRATEGY FOR MITIGATING THE IMPACTS OF CLIMATE CHANGE IN KENYA

The NCCRS's primary focus is ensuring that adaptation and mitigation measures are integrated in all government planning and development objectives.

- enhancing understanding of the global climate change negotiations process, international agreements, policies and processes and most importantly the positions Kenya needs to take in order to maximise beneficial effects,
- assessing the evidence and impacts of climate change in Kenya,
- recommending robust adaptation and mitigation measures needed to minimise risks associated with climate change while maximising opportunities,
- enhancing understanding of climate change and its impacts nationally and in local regions,
- recommending vulnerability assessment, impacts monitoring and capacity building framework needs,
- recommending research and technological needs and avenues for transferring existing technologies,
- providing a conducive and enabling policy, legal and institutional framework to combat climate change, and
- providing a concerted action plan, resource mobilisation plan and robust monitoring and evaluation plan.

This Strategy is expounded in the Kenya National Climate Change Response Strategy (NCCRS)¹⁸.

6. ADAPTATION STRATEGY AND MITIGATION INTERVENTIONS

Adaptation to global warming covers all actions aimed at coping with climatic changes that cannot be avoided and at reducing their negative effects. Adaptation measures include the prevention, tolerance or sharing of losses, changes in land use or activities, changes of location, and restoration. The primary reason for adaptation is that the GHGs already

¹⁸. Government of Kenya, 'Kenya National Climate Change Response Strategy', 2010.

present in the atmosphere are enough to cause significant climate change, irrespective of if all emissions were stopped today. Anthropogenic climate change is already occurring: glaciers are melting, sea levels are rising, and desertification is increasing. With rising carbon dioxide levels, climate change is likely to worsen. For these reasons, the world must prepare for and adapt to the effects of global warming through adaptation actions and policies that are designed to tackle both current and future climate change threats.

Strategies identified in the Kenya NCCRS include:

- Strategies for the agriculture, horticulture and food security.
- Strategies for livestock/pastoralism.
- Strategies for water resources enhancement.
- Strategies for health enhancement.
- Strategies for forestry sector.
- Strategies for rangelands, wildlife and tourism.
- Strategy for social infrastructure and human settlements.
- Strategy for physical infrastructure.
- Strategy for fisheries, coastal and marine ecosystems.

Mitigation refers to efforts that seek to prevent or slow down the increase of atmospheric GHG concentrations by limiting current and future emissions and enhancing potential sinks for GHGs. In Kenya, the sectors associated with high emissions include forestry as a result of logging; agriculture; energy and transport.

The sectors covered in the mitigation measures include:

- Forestry.
- Energy.
 - Acceleration of the development of geothermal energy.
 - Acceleration of the development of green energy (wind, solar and renewable biomass).
 - Energy efficiency.
- Agriculture.
- Transport.

7. CARBON MARKETS, BENEFITTING OF MITIGATION

Developing countries can initiate projects that can gain monetarily from ‘carbon markets’ that allow them to sell certified emission reduction (CER) credits to developed countries (also known as Annex 1) to help the latter cost-effectively mitigate against climate change. This is legislated under the Kyoto Protocol’s CDM compliance markets. Carbon markets also comprise of the buying of ‘carbon offsets’ by individuals and organisations who wish to voluntarily offset their GHG emissions, i.e. under the Voluntary Carbon Markets (VCM).

7.1. The clean development mechanism (cdm)

In order for Kenya to participate effectively in the carbon markets including the CDM, the following measures will need to be undertaken:

- calculation of the baseline GHG Grid Emission Factor (GEF) for the electricity grid of Kenya to facilitate CDM projects in the power sector and assist carbon project developers and consultants,
- target capacity building for the private sector and investors to increase the knowledge of GHG reduction project development and markets, e.g. developing a handbook for CDM Project Activities detailing the role of government and the UNFCCC, CDM cycle, types of projects, eligibility criteria, CDM transaction costs and how to sell Certified Emission Reductions (CERs),
- need for a government-fronted manual that guides CDM implementation; this can be placed on a public website, as has been done by a number of countries including Tanzania,
- strengthening relevant institutions such as the DNA and removing barriers to carbon trading such as high initial transaction costs and low level of awareness of CDM potential on the part of private sector, particularly investment and financial organisations,
- providing tax incentives and favourable import tariffs on technology for projects that reduce emissions,
- having clear energy pricing and CDM project policies including a general institutional framework and good governance,
- ensuring that Kenya establishes itself as a cost-effective host country to GHG emission reduction projects,
- designing a general ranking of the easiest and most viable project types to the most difficult and least viable (low hanging fruits first to build momentum),
- creating a database of existing projects, emission reduction volumes, other benefits, project developers, financiers, government support, and
- exploring ways of integrating carbon markets into the main economy and opening it to conventional legal and banking systems.

7.2. Communication, education and awareness programmes

Kenya needs to borrow from the Communication, Education and Public Awareness (CEPA) 44 programme of the Conventions on Biological Diversity (CBD), an effective public education and awareness programme on climate change will entail:

- communicating the scientific and technical work of the UNFCCC, the Kyoto Protocol, and the post Kyoto agreement documents in a language that is accessible to many different groups,
- integrating climate change into education systems of all Parties to the Convention, and
- raising public awareness of the importance of climate change and its implications to our lives.

The essential characteristics of such communication models should include:

- community ownership and participation through ensuring local content,
- language and cultural relevance,
- using appropriate technology that can be owned and controlled by the people to meet their real needs, and
- learning and sharing among networks of people with similar concerns.

The following measures should be pursued for the education programs:

- Curricula review to integrate climate change into education systems: The Ministry of Education should incorporate climate change into school curricula at all levels as part of education and public awareness.
- Develop, strengthen and harmonise national education, research institutions and programmes on issues regarding the impacts of, adaptation to and mitigation against climate change.
- Involvement of local administration and community leaders in aspects of the education programs.
- Developing and disseminating climate change literature in local languages for the benefit of marginalised populations and the general public,

Some ways of raising public awareness include:

- establishing a National Climate Change Awareness campaign. The National AIDS/STD Control Programme model for sexually transmitted diseases can be adapted,
- using print and electronic media to pass climate change information in various articles and programmes on climate change in the media,
- Education-based entertainment: educating the citizens on climate change while entertaining them at the same time through theatrical performances,
- mainstreaming climate change awareness in all programmes and projects undertaken by the Government, NGOs, CBOs, media etc,
- creating climate change training material and programmes for target groups of stakeholders and specific groups, i.e. women, men children, youth, people with disabilities, religious groups,
- promotional activities and sponsorship of events with climate change themes, e.g. a reward scheme for pupils or individuals who plant trees and maintain them.

7.3. Vulnerability assessment, impact monitoring and capacity building

The IPCC defines vulnerability as ‘the extent to which climate change may damage or harm a system’ and adds that ‘vulnerability depends not only on a system’s sensitivity, but also on its ability to adapt to new climatic conditions.’ Monitoring of the GHG emissions requires setting up the following training and capacity building activities:

- regional and sub-regional preparatory workshops for climate change negotiators where

Kenya would participate with other developing countries, SIDS and LDCs, on the UNFCCC negotiation process,

- technical and policy support to Kenya as a party to the UNFCCC for preparing its National Communications,
- support to the country in its efforts to implement UNFCCC decisions through country-driven approaches,
- awareness-raising, development of communication tools, training and planning workshops at local, national, regional and global levels,
- capacity building and support for the modernisation and development of national meteorological services e.g. the Kenya Meteorological Department and IGAD Climate Prediction and Applications Centre (ICPAC).

THE IMPACT OF DROUGHT AND DESERTIFICATION ON ETHIOPIA

1. INTRODUCTION

Developing countries in general and least developed countries like Ethiopia in particular are more vulnerable to the adverse impacts of climate variability and change. This is due to their low adaptive capacity and high sensitivity of their socio-economic systems to climate variability and change¹⁹.

The main environmental problems in the country include land degradation, soil erosion, and deforestation, loss of biodiversity, desertification, recurrent drought, flood and water and air pollution. The National Adaptation Programme of Action (NAPA) is a mechanism within the UNFCCC, designed to help the Least Developed Countries (LDCs) including Ethiopia to identify their priority adaptation needs to climate change and to communicate these needs to the Conference of Parties (COP) of the UNFCCC and other concerned bodies.

A large part of the country is dry sub-humid, semi-arid and arid, which is prone to desertification and drought. The country has also fragile highland ecosystems that are currently under stress due to population pressure and associated socio-economic practices. Ethiopia's history is associated, more often than not, with major natural and man-made hazards that have been affecting the population from time to time. Drought and famine, floods, malaria, land degradation, livestock diseases, insect pests and earthquakes have been the main sources of risk and vulnerability in most parts of the country. Recurrent droughts, famines and, recently, floods are the main problems that affect millions of people in the country almost every year. While the causes of most disasters are climate related, the deterioration of the natural environment due to unchecked human activities and poverty has further exacerbated the situation.

The expansion of agriculture usually takes place at the expense of the natural vegetation, particularly forests, woodlands and other wildlife resources, leading to loss of both flora and fauna, and ultimately, destruction of habitats as a whole. Some wild relatives of cultivated crops are also threatened by such habitat destruction. The rate of deforestation due to mainly agricultural expansion and fuel wood gathering is remarkably high. This process has immense impacts on biodiversity and ultimately leads to desertification.

2. POLICIES

The Environmental Policy of Ethiopia, an umbrella policy composed of 10 sectoral and

¹⁹. Government of Ethiopia, 'National Adaptation Plan of Action' (NAPA), 2007.

10 cross-sectoral environmental policies, has been formulated and approved by the government in 1997 to promote sustainable socioeconomic development through sound management and rational use of natural resources and the environment. The Policy includes implementation issues like institutional coordination, legislative framework and monitoring, evaluation and review provisions. The Policy also emphasizes the need for environmental sustainability to be recognized in other policies and strategies as a key prerequisite.

Climate Change and Air Pollution is among the ten sectoral environmental policies. The overall objectives of this policy are to:

- promote climate monitoring programs as the country is sensitive to changes in climate,
- recognize that a firm and demonstrable commitment to the principle of containing climate change, and
- foster use of hydro, geothermal and solar energy so as to minimize emission of greenhouse gases (GHGs).

3. NATIONAL ADAPTATION PROGRAMME OF ACTION (NAPA)²⁰

The National Adaptation Programme of Action (NAPA) is a mechanism within the UNFCCC, designed to help the Least Developed Countries (LDCs) including Ethiopia to identify their priority adaptation needs to climate change and to communicate these needs to the Conference of Parties (COP) of the UNFCCC and other concerned bodies.

The purpose of the NAPA is therefore to identify immediate and urgent adaptation activities that address current and anticipated adverse effects of climate change including extreme climate events. It provides a flexible framework to guide the coordination and implementation of adaptation initiatives in the country through a participatory approach; building synergies with other relevant environmental and related programs and projects.

4. SITUATION ANALYSIS

4.1. Rainfall

Rainfall in Ethiopia occurs in three seasons known as the Bega (dry season) which extends from October-January, Belg (short rain season) which extends from (February-May), and Kiremt (long rain season) which extends from June-September. Mean annual rainfall distribution over the country is characterized by large spatial variations which range from about 2,000 mm over some areas in the Southwest to less than 250 mm over the Afar and Ogaden low lands.

The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country over the period 1971-2000.

²⁰ Government of Ethiopia, 'National Adaptation Programme of Action', 2007.

4.2. The drought situation in Ethiopia

Ethiopia has been known for acute drought and famine periods that claimed away thousands of lives. Late rains and below average rainfall at critical times of the year induce droughts, lowering crop yields and causing food insecurity. The problem is exacerbated during years of below average rainfall. Severe droughts have occurred in Ethiopia in 1965, 1969, 1973, 1977, 1978-1979, 1983-1984, 1987, 1989-1992, 2000 and 2002. During droughts, yields and discharges of water from different sources (lakes, springs, rivers and ground water sources) are reduced. Most recently, below average rainfall between 1999 and 2002 resulted in four years of limited food production and severely depleted the asset base of the population across much of the country. There will be significant adverse impact on people and degradation of important habitats if the drought period elongates. Availability and quality of water deteriorates as dilution effects are reduced.

Reports indicated the extreme sensitivity of the country to climatic variability as over 83% of the population relies on agriculture practice based on rain-fed crop production. Projection of climate models with a rise in temperature and increase in rainfall variability depict higher frequency of extreme flooding and drought for Ethiopia; areas with higher rainfall are likely to obtain even high amount of rainfall and the reverse for lowlands, with limited rainfall. Climate variability from increased temperature will consequently result in increased evapotranspiration, increased water stress, reduction in crop and forage yield, increased stress on farmers and pastoralists, weaker local and national economy.

The prediction made on climate change and its influence on agricultural practice is very dim for Ethiopia; yields could drop by around 50% by the year 2020. The risk of drought will remain or even increase as factors contributing to climate change, land degradation and most of all reliance on rainfed agriculture continue by majority of the people in the country²¹.

4.3. Drought prone areas and affected people

As indicated above the drought situation is the most serious widespread problem to Ethiopia, the situation gave Ethiopia and its people as a good example of drought cases description. The FDRE is working hard to put an end to drought and poverty in the country. National economic development achievement for successive years (averaged of 6 % growth) through the PASDEP can be considered as an indicator. The most recent worst drought year was 2003 when below average spring (belg) rains in March to May were followed by delayed and sporadic main rains from July to September which led to widespread food insecurity.

During this period, over 11 million people were affected by drought waiting for emergency food assistance as reported by the ex-DPPC. The worst hit areas were the pastoral and agricultural areas of the lowlands and midlands for the SNNP, Tigray, Oromiya, Amhara, Somali and Afar Regions. The consequences of drought continue after the rains return due to the time lags between receiving aid to start cultivation (seeds), planting and harvesting. Even by the start of 2006 (which was a particularly wet year) much of lowland continued to

²¹. Government of Ethiopia, Final Environment Report, prepared for the SSO Project, Oct. 2009.

be under severe drought conditions.

Areas that are venerable to drought are identified based on drought information obtained from the DMFS of the MoARD. The office has a database on the drought areas, affected people and crop and other assets and rehabilitation assistance made for several years. Frequency of drought hazard was developed by disaster management & food security of the MoARD for different areas based on information for the year 1975 to 2007. Drought occurs most frequently in the eastern and north eastern part of the country. It’s a matter of frequency, otherwise majority of the eastern, southern and north eastern part of the country faces with recurrent drought. No drought has been recorded for the period in some pocket part of the northern, western and central Ethiopian highlands (Figure 4-2).

4.4. Prevention of drought

Until 1973, there was no organized disaster management institution and the response to drought made by an ad hoc committee and the communities themselves. Presently, the Disaster Management & Food Security division under the MoARD is responsible for an early assessment of draught and other natural calamities, requirements, response and prevention measures through organizing and coordinating effort with all relevant government, NGOs and international humanitarian agencies. It’s only a matter of magnitude; otherwise Ethiopia has remained to be one of the highest food aid recipients from the international humanitarian communities. This will remain for some years to come till the initiated projects/programs to end poverty in the shortest possible time became fully operational to improve economic growth at local HH and country level and their sustainability ensured. Contribution from donors to response of emergency food ranges from 30 to over 100 %, the average response being 79 % of the total food requirement (Table 2).

Year	Population needing emergency food	Estimated food (Mt) requirement	Donors contribution in Mt	Distributed food (Mt)	Distribution in %
1998	4,096,390	614,470		306,400	50
1999	7,186,860	775,554		502,600	65
2000	10,563,860	1,380,201		999,100	72
2001	6,515,902	639,246	519,401	575,670	90
2002	7,703,993	897,299	710,561	581,462	65
2003	11,320,400	1,802,185	1,700,000	1,600,000	89
2004	7,181,400	1,209,334	980,289	856,200	71
2005	3,806,797	600,000	668,378	456,200	76
2006	3,626,510	507,800	193,039	329,221	65
2007	1,687,178	182,431	124,044	150,580	83

Government of Ethiopia, *ibid.*

TABLE 2. Population in Ethiopia requiring food aid owing to drought effects (1997-2007)

4.5. Temperature

The country experiences mild temperatures for its tropical latitude because of its varied

topography. Mean annual temperature distribution over the country varies from about 10°C over the highlands of northwest, central and southeast to about 35°C over north-eastern lowlands.

The year to year variation of annual minimum temperatures expressed in terms of temperature differences from the mean and averaged over 40 stations clearly reveals that there has been a warming trend in the annual minimum temperature over the past 55 years. It has been increasing by about 0.37 °C every ten years.

5. IMPACTS OF CURRENT CLIMATE VARIABILITY IN ETHIOPIA

The major adverse impacts of climate variability in Ethiopia include:

- Food insecurity arising from occurrences of droughts and floods: drought is the single most important climate related natural hazard impacting the country from time to time. Recurrent drought events in the past have resulted in huge loss of life and property as well as migration of people to mainly the urban centres, thus creating increased urbanisation.
- Flash and seasonal river floods affect areas in the Afar Region along the Awash River, in the Somali Region along the Wabi Shebele River and in the Gambela Region along the Baro-Akobo River, in the Southern Region along the Omo-Gibe River, Bahirdar Zuria and Fogera areas along the Abbay River in the Amhara Region.
- Outbreak of diseases such as malaria, dengue fever, water borne diseases (such as cholera, dysentery) associated with floods and respiratory diseases associated with droughts;
- Land degradation due to heavy rainfall;
- Damage to communication, road and other infrastructure by floods.

6. CAUSES OF VULNERABILITY TO CLIMATE CONDITIONS IN ETHIOPIA

Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity and inadequate road infrastructure in drought prone areas, weak institutions and lack of awareness (Table 3).

Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are agriculture, water and human health. In terms of livelihood approach, smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by drought.

7. COPING MECHANISMS FOR CLIMATE VARIABILITY

- Strengthening capacity in terms of developing methods, tools, institutions and individuals to produce, disseminate and apply climate information.

Sector	Potential impacts
Agriculture	Shortening of maturity period and decrease in crop yields
Grassland and livestock	<ul style="list-style-type: none"> • Change in livestock feed availability • Effects of climate change on animal health, growth and reproduction • Impacts on forage crops quality and quantity • Change in distribution of diseases • Changes in decomposition rate • Change in income and prices • Contracting pastoral zones in many parts of the country
Forests	<ul style="list-style-type: none"> • Expansion of tropical dry forests and the disappearance of lower montane wet forests; • Expansion of desertification
Water Resources	<ul style="list-style-type: none"> • Decrease in river run-off • Decrease in energy production • Flood and drought impacts
Human Health	Expansion of malaria to highland areas
Wildlife	<ul style="list-style-type: none"> • Shift in physiological responses of individual organisms • Shift in species distribution from one to the next • Shift in biomes over decades/centuries • Shifts in genetic makeup of population • Loss of key wetland stopover and breeding sites for threatened bird species; • and in general endemic and threatened species of flora and fauna are frontline victims

TABLE 3. Summary of impact/Vulnerability Assessment for the selected sectors.

- Other important coping mechanisms to climate variability and extreme in Ethiopia include:
 - Changes in cropping and planting practices,
 - Reduction of consumption levels,
 - Collection of wild foods,
 - Use of inter-household transfers and loans,
 - Increased petty commodity production,
 - Temporary and permanent migration in search of employment,
 - Grain storage,
 - Sale of assets such as livestock and agricultural tools,
 - Mortgaging of land,
 - Credit from merchants and money lenders,
 - Use of early warning system,
 - Donor aid.

8. POTENTIAL BARRIERS TO IMPLEMENTATION OF THE NAPA

Some of the major barriers for adaptation gains from the ongoing national initiatives include:

- Lack of strong coordination mechanism both at the federal and regional levels to

maximize climate change adaptation gains from the ongoing and planned national initiatives – action plans, policies/ programmes and projects;

- Inadequacy of cross-sectoral links of the ministries and line departments;
- Lack of elaborated links of federal and regional sector offices as well as cross sectoral federal committees involved in environmental and developmental issues;
- Lack of capacity;
- Lack of efficient outreach mechanism on environment to local communities;
- Oversight of long-term environmental impacts of short-term economic benefits;
- Economic challenge, i.e., limited finance for environment;
- Low level of awareness about the environment;
- Low level of public literacy;
- High level of poverty;
- Inadequate capacity on information exchange among NMA and NAPA project and/or action plan implementers:

The following recommendations are suggested in order to maximize climate change adaptation gains from the existing or planned national initiatives:

- The focal institution and the key climate change relevant project implementers should be well connected with efficient information and networking system;
- Key climate change adaptation relevant project implementers should be well acquainted and familiar with objectives of the NAPA;
- Strengthen the focal institution with the required infrastructure, facilities and manpower; and
- Mainstream climate change adaptation options into relevant policy/ programmes - agriculture, health and water programmes indicated in the PASDEP.

9. ADAPTATION OPTIONS IN THE INITIAL NATIONAL COMMUNICATION TO THE UNFCCC

The NAPA Ethiopia describes some options that the country will have to implement to increase its adaptation to climate change.

Sectors	Proposed adaptation options
Agriculture: crop, livestock & rangeland (relevant crosscutting adaptation options)	<ul style="list-style-type: none"> Capacity building and institutional strengthening of the local community Community empowerment for improved agricultural production and natural resources conservation Restrict free range grazing and promotion of stall feeding Water resources development Control and management of Invasive Alien Species (IAS) Introduction of various agro forestry systems in the existing farming systems Promotion of renewable energy sources to minimize the use of agricultural residues for house hold energy rather than using it as soil conditioner to enhance soil fertility and there by agricultural productivity and production Conservation of Agro biodiversity resources Establishment of fodder factory

Sectors	Proposed adaptation options
Agriculture: Crop	<ul style="list-style-type: none"> • Enhancing erosion control • Improve and changing management practices and techniques such as planting date, seedling rate, fertilizer application rate, etc • Engagement in obtaining food from other sources and income generating activities in times of crises • Proper use of climate information for land use planning and early warning systems, etc • Grow crops which requires less water
Agriculture: Grassland & livestock (lowlands/rangelands)	<ul style="list-style-type: none"> • Introduce mixed farming system, where appropriate De-stocking of livestock on a regular basis Promote lifestyle choices of pastoralists through access to education and local urban development Conservation and utilization of hay from natural pastures • Promotion of grazing management schemes • Integrated approach for pastoral development • Rehabilitation of bush encroached areas • Promote traditional range conservation and management systems • Use of local legume forage including Acacia fruits and leaves, • Promotion of irrigation for agricultural development • Establish community gene banks specially for drought and diseases resistant land races
Water resources	<ul style="list-style-type: none"> • Allocation of water supply through market based systems • Conservation of water and use of river basin planning and coordination • Flood control • Combating drought • Construction of reservoirs for hydropower, irrigation, water supply, flood control over and /or multipurpose uses and establishment of flood forecasting and drought monitoring system have been identified as high effective climate adaptation options in the Abay Basin (FNRC) 2001) • Improve the underground water resources potential and management • Promotion of water resources saving techniques in drought and climate change vulnerable areas • Introduction of Fish Ponds; establishing, legalization and regulation of fish resource exploitation • Introduction of water quality monitoring systems • Building upon the existing traditional irrigation systems by the local communities/Water resource users through capacity building • Integrate and implement climate adaptation options in the River basin master plan studies • Introduce wise use and management of wetlands to improve among others recharging capacity of underground water • Undertake study on the possible future demand for water by considering future development plans from the rift valley lakes and establish a system to control the amount of water to be abstracted from the lakes • Introduce drip irrigation system • Introduction of integrated watershed management for the management of the vegetation cover and abatement of erosion and siltation of water bodies • Regulation and prevention of discharged of domestic and industrial organic wastes as well as toxic chemical pollutants that cause hazards from entering into water bodies

Sectors	Proposed adaptation options
Agriculture: Grassland & livestock (highlands)	<ul style="list-style-type: none"> • Selection of crops and cropping systems that maximize biomass production and therefore, CO₂ and N₂ fixation • Improve animal genotype and better disease parasite control to take advantage of the improved management • Use of multipurpose cattle that work and provide milk and meat and also breed to provide suitable draught animals, in addition to supplying fuel and fertilizer from their excreta

TABLE 4. Adaptation Options as Proposed in the Initial National Communication tot the UNFCCC.

THE IMPACT OF DROUGHT AND DESERTIFICATION ON SUDAN

1. INTRODUCTION

Desertification is listed as the main environmental problem for Sudan with one study indicating that thirteen of the 26 Sudan's states could be classified as desert or semi-desert^{22, 23}.

Important Note: at the time of completing this study, Sudan got divided into two states: Sudan and South Sudan following the independence of the latter on 9th July 2011. The impact of the separation of the two states on the narrative below is not analysed. The narrative uses the information available for the two states of Sudan and South Sudan before the independence of South Sudan.

Sudan is the largest country in Africa. Its total area is over 250 million hectares, much of which is comprised of arid lands and desert. Throughout much of the country, water resources are limited, soil fertility is low, and drought is common. These underlying conditions are exacerbated by range of human pressures, creating a situation in which Sudan is already highly vulnerable to current climatic shocks. Sudan's population was estimated in 2007 at over 37 million, with an annual growth rate of 2.63%, which is rather high.

The population density is about 10 people per square kilometre, though density per square kilometre of arable land is considerably higher – 63 people per square kilometre – and higher still on cultivated land where there are about 370 people per square kilometre. Much of the population is clustered in central Sudan and along the Nile River.

Rainfall, which supports the overwhelming majority of the country's agricultural activity, is erratic and varies significantly from the northern to southern ranges of the country. The unreliable nature of rainfall, together with its concentration in short growing seasons, heightens the vulnerability of Sudan's rain-fed agricultural systems.

The most extreme temperatures are found in the far northern part of the country, where summer temperatures can often exceed 43°C and sandstorms blow across the Sahara from April to September. These regions typically experience virtually no rainfall. In the central

²². Government of Sudan, 'Final Environment Report for Sudan', one of the national reports prepared under the OSS.

²³. Government of Sudan, 'National Adaptation Program of Action', 2007.

area around and just south of Khartoum, average annual temperatures are around 27°C, with rainfall averaging about 200 mm/year and rarely exceeding 700 mm/year.

In the southern regions of Sudan, climatic conditions are more equatorial with average annual temperature of about 29°C and average annual rainfall greater than is over 1,000 mm/year. Most of this rainfall occurs during the rainy season from March to October when humidity levels can be very high.

Sudan's land and water resources can be classified into the following major ecological regions, as described below.

- **Arid and semi-arid ecosystems.** These areas in the northern and central parts of the country; they represent over 50% of total area with about 125 million hectares;
- **Savannah ecosystems (clay).** These areas are typified by low rainfall and the prevalence of clay soils; they represent about 5% of total area with about 12 million hectares;
- **Savannah ecosystems (sand).** These areas are typified by low rainfall and the prevalence of sandy soils; they represent about 3% of total area with about 8 million hectares; and
- **Southern flood-prone ecosystems.** These areas are located below latitude 10° north; they represent about 3% of the total area with about 8.5 million hectares.

Traditional subsistence agriculture dominates the Sudanese economy, with over 80% of the population dependent upon crop production and/or livestock husbandry to support their livelihoods. Agricultural activities account for nearly half of GDP, and are responsible for the vast majority of employment.

The agricultural sector is dominated by small-scale farmers. Typically, such farmers are living in conditions of persistent poverty and rely on rain-fed and traditional practices. This combination renders them highly vulnerable to climate variability, as evidenced by the widespread suffering in rural areas during past droughts.

Chronic drought is one of the most important climate risks facing Sudan. Recurring series of dry years has become a normal occurrence in the Sudano-Sahel region. Drought is threatening the cultivation of about 12 million hectares of rainfed, mechanized farming and 6.6 million hectares of traditional rainfed lands. Pastoral and nomadic groups in the semi-arid areas of Sudan are also affected.

Sudan's diverse agro-ecological zones and abundant surface water offer the potential to produce a range of crops, as well as livestock. Yet, production remains consistently low due in large part to an agricultural system that is not well adapted to rainfall variability and prolonged drought events.

Land degradation and desertification, brought about by human land-use pressures and recurrent drought, has degraded large areas of Sudan and continues to threaten already vulnerable arable zones. Depletion of forests – primarily for household fuel use – threatens biological diversity, human communities, and reduces other valuable services forests provide. Industrial and human waste discharges impact water quality for communities that are already water-stressed.

Natural disasters in the contrasting forms of drought and flooding have historically occurred frequently in Sudan, and have contributed significantly to population displacement and the underdevelopment of the country. A silent and even greater disaster is the ongoing process of desertification, driven by climate change, drought, and the impact of human activities (Figure 7). In Sudan, desertification is clearly linked to conflict, as there are strong indications that the hardship caused to pastoralist societies by desertification is one of the underlying causes of the current war in Darfur. Given the severity of the impact of such events and processes, there is a clear and urgent need for improved climate analysis, disaster prediction and risk reduction for Sudan in general, and for Darfur in particular. The current and forecast impact of desertification, especially, is poorly understood, and major efforts are required to investigate, anticipate and correct this phenomenon²⁴.

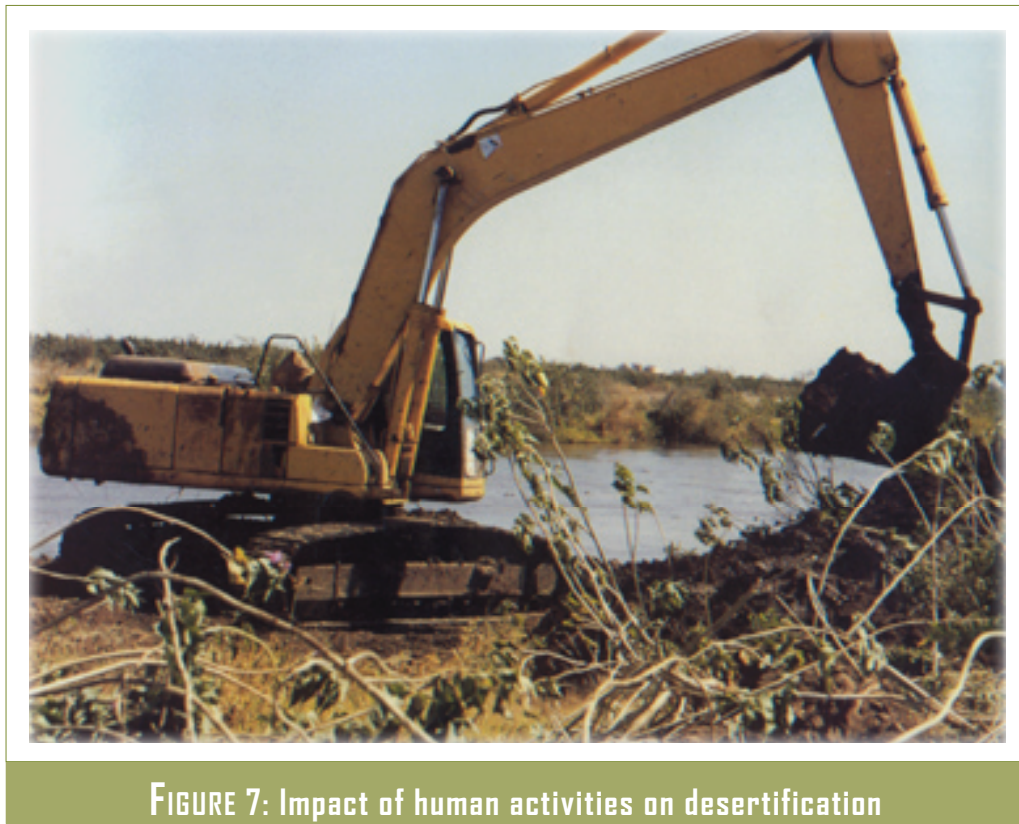


FIGURE 7: Impact of human activities on desertification

2. DROUGHT TRENDS

Vulnerability of communities and economic sectors to climate-related impacts is associated with weather fluctuations in the near term (i.e., climate variability), as well as fluctuations in weather patterns over the long term (i.e., climate change).

Rainfall patterns in cities located in each of the ecological zones of Sudan for the periods 1941-1970, 1951-1980, 1961-1990 and 1971-2000 show two important trends for this sixty-year period. First, average annual rainfall has declined from about 425 mm/year to about 360 mm/year, a decrease of annual rainfall of about 0.5% per year. Secondly, the

²⁴. Government of Sudan, Final Environment Report prepared for the SSO Project, 2009.

coefficient of variability of rainfall shows an overall increasing trend, suggesting greater rainfall unreliability²⁵.

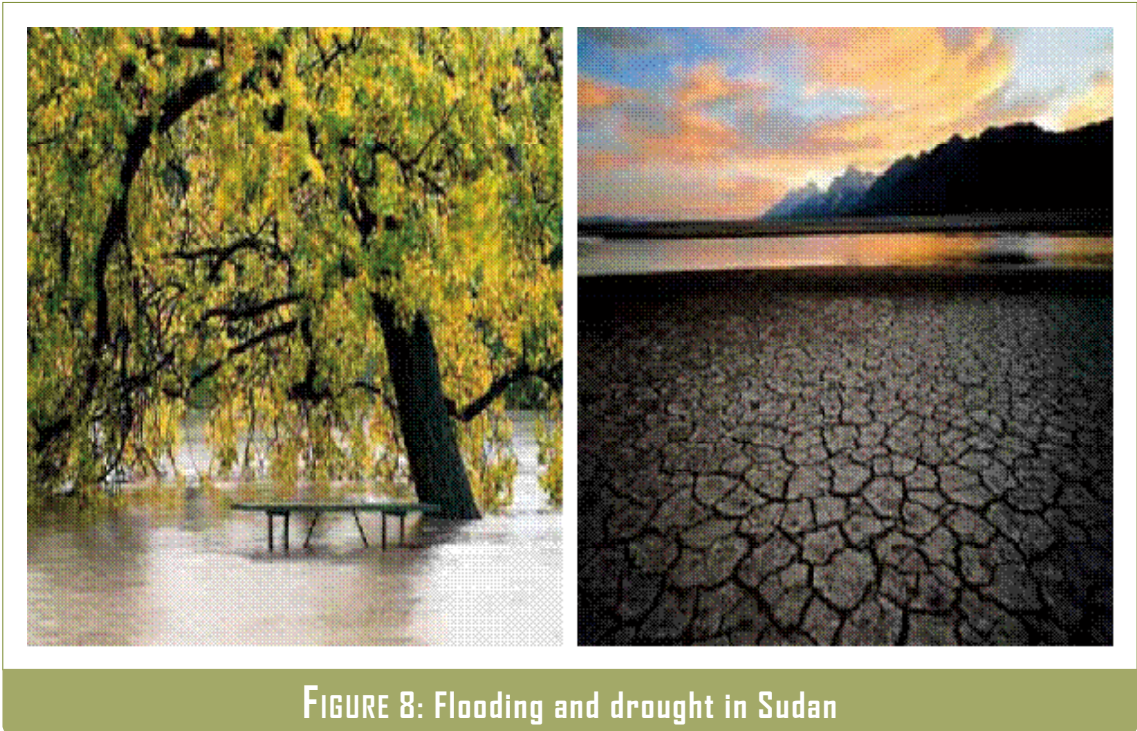
The variability in rainfall is most serious in the arid northern parts of the country where the average variability now exceeds 100%. The situation is less serious in the central parts of the country, where average rainfall variability ranges from 20% to 60% and in the South, where it varies between 15% and 20%. However, at the national level, there is a trend of greater rainfall variability in Sudan, increasing at a rate of about 0.2% per year. Drought (Figure 8) problems in Sudan will increase if the above trends continue without efforts to adapt.

3. FLOODING TRENDS

Sudan has experienced many devastating floods (Figure 8) and droughts spells during the past several decades. These events have led to widespread loss of property, damage to irrigation facilities and water services and the spread of waterborne diseases.

The discharge levels from the Ethiopian Plateau (the source of the Blue Nile waters) are highly variable, and the region is highly prone to the extremes of floods and droughts. During exceptional wet periods, the three major rivers in the region of the Blue Nile, Atbara and the Sobat Rivers can give rise to large-scale flooding, particularly in the floodplain areas of south-eastern Sudan.

Flooding occurs during torrential rains when high levels of water overflow the Nile River and its tributaries. This type of flood occurs mainly during the rainy season (around autumn). These floods were reported in 1946, 1988, 1994, 1998, 1999 and 2001, showing an increasing frequency.



²⁵. Government of Sudan, *ibid.*

Flash flooding, which occurs from heavy localized rainfall during the rainy summer season or over the Red Sea area in winter season due to mountain runoff, was reported in 1952, 1962-65, 1978-79, and 1997, with increasing frequency.

4. EXPECTED IMPACTS FROM FUTURE CLIMATE CHANGE

Climate scenario analyses conducted as part of the preparation of Sudan's First National Communications indicate that average temperatures are expected to rise significantly relative to baseline expectations. By 2060, the projected warming ranges from 1.5 °C to 3.1 °C during August to between 1.1 °C to 2.1 °C during the month of January.

Projections of rainfall under climate change conditions also show sharp deviations from baseline expectations. Results from some of the models show average rainfall decrease of about 6 mm/month during the rainy season. Such changes in temperatures and precipitation will adversely affect sustaining the development progress that has achieved in many sectors in Sudan. The three highest priority sectors where urgent and immediate action is needed were identified through the NAPA consultation process to be agriculture, water, and public health.

4.1. Agriculture

Combined with growing socioeconomic pressures, the imposition of climate variability and climate change is likely to intensify the ongoing process of desertification of arable areas. Humid agro climatic zones will shift southward, rendering areas of the North increasingly unsuitable for agriculture. Crop production is predicted to decline substantially for both millet and sorghum. The area of arable land (Fig. 9) as well as the important Gum Arabic belt would likely also decrease, with attendant impacts on both local incomes and food security would drop.



4.2. Water resources

Reduced groundwater recharge – either through decreased precipitation or increased temperature and evaporation – has grave repercussions for Sudan. National studies have shown that soil moisture would decline under future climate change. When coupled with increased water consumption, population growth, high variation in rainfall and the high rate of evaporation, a looming water crisis appears likely.

4.3. Public health

Communities in Sudan would be exposed to significantly increased risk of malaria under climate change. Studies in Kordofan State, for example, have shown that the risk of transmission potential could increase substantially by 2060. If realized, not only would the overburdened health care system experience extreme stress but the disease would exact a heavy toll on local communities²⁶.

5. EFFORTS TO MAINSTREAM CLIMATE CHANGE ADAPTATION IN NATIONAL POLICY MAKING

Sudan has mainstreamed adaptation to climate change in the development process, by inclusion of climate and vulnerability in sectoral and development policies that are complementary to the climate change. Environmental policies are embodied in the 10-year Comprehensive National Strategy (1992-2002) and the 25-year comprehensive National Strategy Outlines. There are many ongoing national policy processes that have parallel aims to climate change adaptation such as those listed below:

Poverty reduction strategy: Major portions of Sudan's interim Poverty Reduction Strategy Paper (2004-2004) focus on agriculture, water resources, and public health -- the very sectors that the NAPA process has targeted. Many of the interim Strategy Paper's specific projects and strategies for responding to the development needs of Sudan's poor populations served as points of departure for NAPA consultations.

Roll Back Malaria Programme: Sudan has implemented a national program called Roll Back Malaria (RBM), which contains a comprehensive approach to improving surveillance and epidemic management, enhancing disease management, and providing options for preventive interventions. Given the potential of climate change to exacerbate the already serious public health challenge of malaria through increased transmission potential, NAPA-RBM coordination has been a major strategy

Water harvesting: As part of several national project, water harvesting techniques have been implemented for nine areas in several states (North Darfur, Nile, North Kordofan, and West Kordofan). These projects have increased community access to reliable water, increasing their capacity to cope with the impacts of reduced precipitation, increased temperature and drought, all of which has been integrated into the NAPA consultation process.

²⁶ Government of Sudan, *ibid*.

6. BARRIERS TO THE IMPLEMENTATION OF NAPA IN SUDAN

Sudan may face numerous challenges and barriers when it comes to the implementation of urgent and immediate activities identified by the NAPA process. These may be summarized as follows:

- Political will and commitment is required for the implementation of NAPA. This implies a sustained process of awareness building among policymakers regarding climate-related risks;
- Capacity, both institutional and individual, at the national and state levels continues to be quite limited and will need sustained strengthening to realize the benefits from the NAPA process;
- Inadequate funding both at the national and international levels threatens to limit the level of implementation of key measures identified in the Sudan NAPA;
- At grassroots levels there continues to be persistent extreme poverty and poor health conditions, which make them more vulnerable to climate change.
- Very poor roads and very far may exceed the cost of activities in certain most vulnerable areas.

7. IDENTIFICATION OF ADAPTATION NEEDS IN SUDAN

Three key areas are identified in the NAPA: agriculture, water resources management and public health.

7.1. Key adaptation activities in agriculture

The most vulnerable groups in Sudan include the traditional rain-fed farmers and pastoralists. This is due primarily to a combination of their extreme poverty levels as well to household income-generating activities that are highly limited. Climatic shocks have generated a chain of events that has led to the disintegration of community and the discontinuity of human habitation in some areas of Sudan.

- Community-based forest and rangeland management and rehabilitation;
- Replacement of household goat herds with sheep herds to reduce pressure on fragile rangelands;
- Lessening of pressure on local forests through use of mud brick building design and alternative energy sources;
- Land use conversion from agricultural activities to livestock raising;
- Strengthening of agricultural and veterinary extension services, including demonstration;
- Introduction of drought-resistant seed varieties, poultry and fish production;
- Reforestation of areas denuded of trees for building construction and firewood;

- Drought early warning systems for disaster preparedness;
- Extension services in agricultural capacity strengthening for small scale farmers; and
- Protection and/or rehabilitation of rangelands, including construction of shelterbelts to reduce windstorm impacts.

7.2. Key adaptation activities in water resource management

- Introduction of new water harvesting/spreading techniques making use of intermediate technologies;
- Promotion of greater use of effective, traditional water conservation practices;
- Rehabilitation of existing dams as well as improvements in water basin infrastructure for increased water storage capacity, particularly in central and western Sudan;
- Construction of dams and water storage facilities in some of water valleys, particularly in western Sudan;
- Introduction of water-conserving agricultural land management practices;
- Improvement of access to groundwater supplies by humans and animals through installation of water pumps;
- Enhancement of capabilities of regional meteorological stations to monitor hydro-climatic variables;
- Introduction of a revolving micro-credit fund to support implementation of small water harvesting projects (Figure 10); and

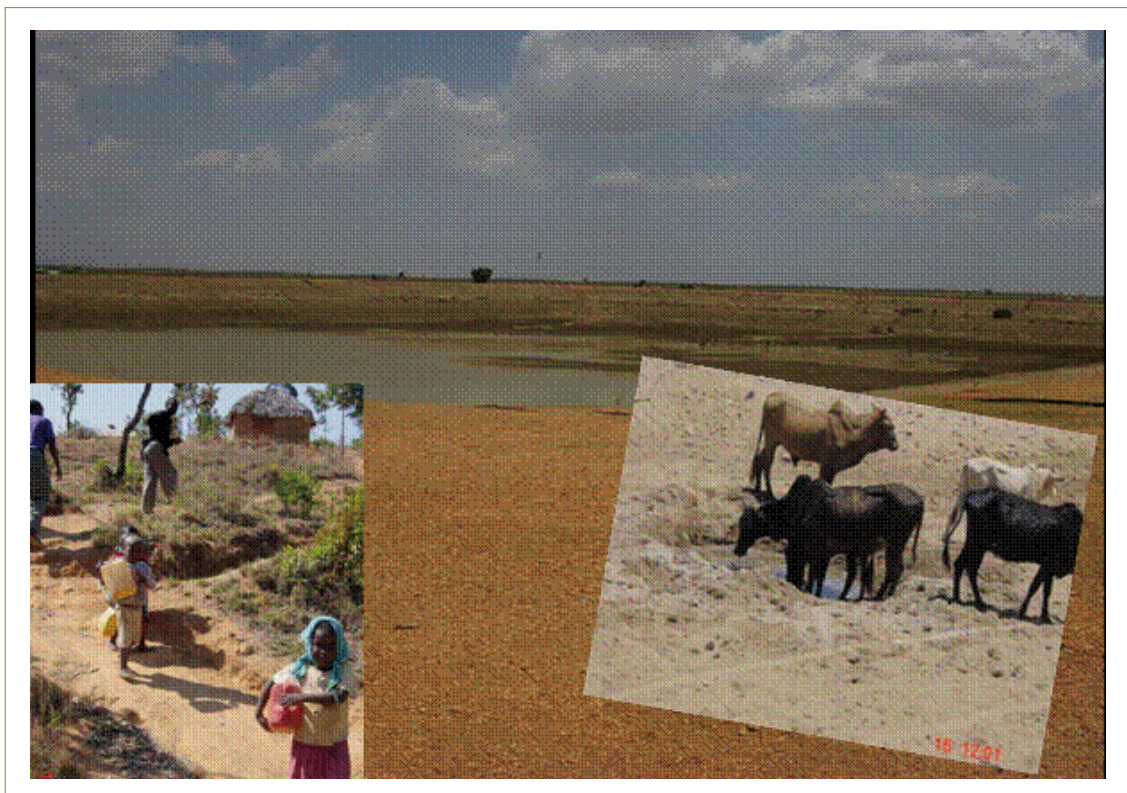


FIGURE 10: Water Harvesting in Sudan

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- Extension services in capacity strengthening in water capture and storage techniques for small-scale farmers.

7.3. Key adaptation activities in public health

Specifically, major adaptation activities and needs across the five ecological zones are as follows:

- Improve community sanitation and medical services, including capacities for diagnosis and treatment;
- Building of community awareness regarding preventative measures for malaria, meningitis, and leishmaniasis;
- Introduction of preventive measures to restrict malaria transmission such as mosquito nets, treatment/drying up of breeding sites;
- Introduction of early disease diagnosis and treatment programmes for malaria, meningitis, and leishmaniasis;
- Improvement of irrigation system management so as to reduce breeding sites; and
- Provision of alternative water supply systems for domestic use that do not involve open standing water areas.

THE IMPACT OF DROUGHT AND DESERTIFICATION ON UGANDA

1. INTRODUCTION

Climate change affects Uganda as well as the other countries in the region, the clearest manifestation of the phenomenon being the disappearance of the ice caps on the Ruwenzori Mountains²⁷.

Uganda lies across the equator and occupies 241,038 square kilometres, of which open water and swamps constitute 43,941 square kilometres. This represents 18.2% of the total area. Most parts are on average height of 1,200 m above sea level. The lowest altitude is 620 m (within the Albert Nile) and the highest altitude (Mt. Ruwenzori Peak) is 5,110 m above sea level. The climate is equatorial, with moderate humid and hot climatic conditions throughout the year. It has two rain seasons in a year, which merge into one long rainy season as you move northwards from the equator. The first rain season is from March to June, while the second season is from August to November.

Uganda's population was at 24.7 million people with a high average growth rate of 3.4% (2002 Census). The rate of population growth is highest in arid areas, averaging 9.7% in Kotido and 6% in Moroto and Nakapiripirit. Thus the highest growth rates are found in the most vulnerable ecosystems.

Climate, perhaps Uganda's most valuable natural resource, is the most neglected. The climate of Uganda is not only a natural resource, but a key determinant of the status of other natural resources, such as water resources, forest, agriculture, ecotourism and wildlife. Uganda has diverse and rich biodiversity, which has provided both food and medicine.

Unsustainable exploitation of these resources, often driven by external market forces, has resulted in serious biodiversity loss with some species being close to extinction. However, climate change which has started manifesting itself through increased frequency of extreme weather events, such as droughts, floods and landslides, is posing a serious threat to Uganda's natural resources, social and economic development.

In Uganda the frequency of droughts has increased, for example seven droughts were experienced between 1991 and 2000.

Frequent droughts have resulted in lowering of the water table, leading to drying of boreholes. The cattle corridor, stretching from the northeast to the southwest is a fragile ecosystem,

²⁷. Government of Uganda, 'Uganda National Adaptation Program of Action', 2007.

and depends on rainwater for human consumption and production. The prolonged and severe drought of 1999/2000 caused severe water shortage, leading to loss of animals, low production of milk, food insecurity, increased food prices and generally negative effects on the economy.

Uganda experiences equatorial climate with moderate temperatures and humid conditions throughout the year. Its location across the Equator gives it two rain seasons in a year, which merge into one long rainy season as you move northwards from the Equator. The first rainy season ranges from March to June, while the second one ranges from August to November. The rainfall level ranges from 400 to 2200 mm per year. Uganda's climate can be broadly characterised into three climatic zones:

- Highland climate zone which has cool temperatures which may fall to below zero in the Rwenzori Mountains and has a mean annual rainfall of 900 mm.
- Savannah tropical climate, including the lake basin climate zone which includes tropical rain forests and wetlands and has a high mean annual rainfall of over 1,200 mm per year.

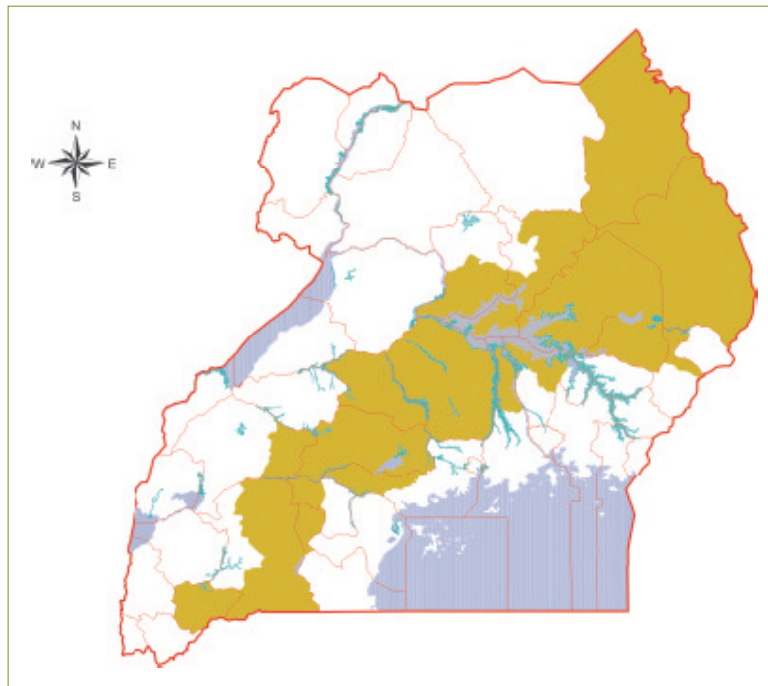
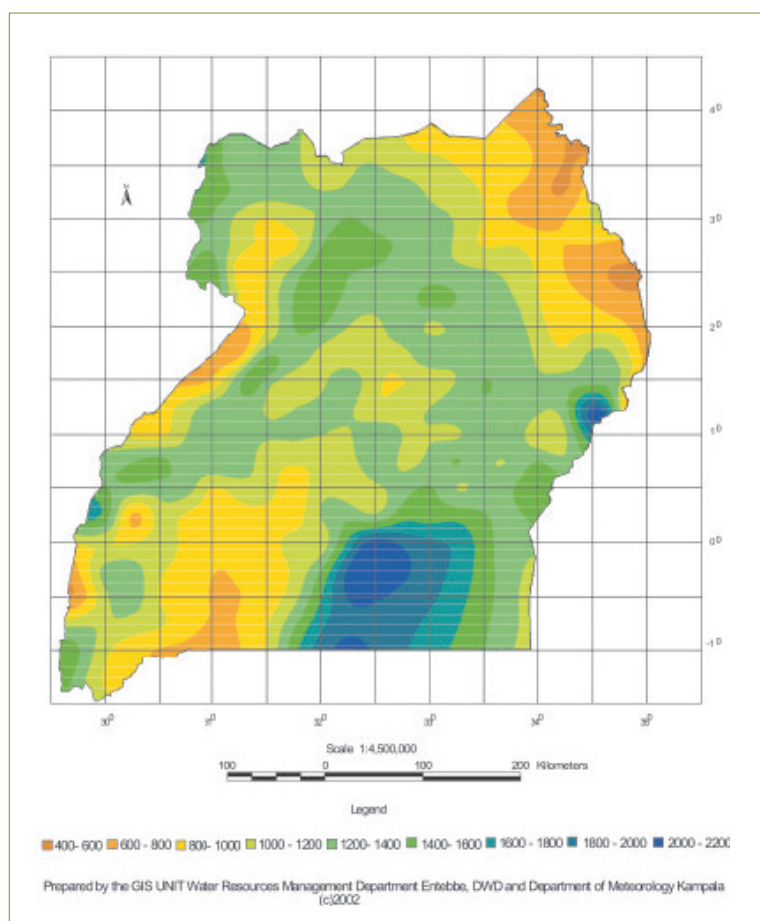


FIGURE 11: Map of Uganda showing the semi-arid cattle corridor and, below, the mean annual rainfall.



Government of Uganda, *ibid.*

■ Semi-arid climate zone: Animal rearing is the dominant activity in this climate zone. The high animal population has led to serious land degradation. Although the mean annual rainfall is relatively low, some drought-tolerant land races can still grow (see Figure 11 for the cattle corridor in Uganda).

The wettest districts are located within the Lake Victoria Basin, eastern and the north-western parts of Uganda. It has been observed that falls are heavier and more violent consistent with the prediction that wetter areas will become wetter. Recent years have witnessed erratic onset and cessation of rainfall seasons.

Forest products (timber, poles, rattan, bamboo, food, fodder, medicine, and firewood etc) and services (biodiversity habitat, moderating of micro climate, shade and wind breaks for enhancing agricultural productivity) play a very important role in the social and economic development of Uganda. The vast majority of Uganda's rural people use wood or charcoal as fuel.

Deforestation is the main environmental issue confronting Uganda's forests, savannah woodlands and bush land. Deforestation is caused by a number of factors, including population increase and poor agricultural practices. Deforestation is a special form of land degradation that occurs in forest ecosystems from where communities derive goods for livelihoods (food, fodder, building materials and fuel) and environmental services that enhance their agricultural production.

2. SPECIFIC BACKGROUND INFORMATION

2.1. Wildlife

Uganda is rich in wildlife, including over 1,000 bird species (over 11% of the world total). There are at least 345 known mammal species, 165 reptile species, 43 amphibian species, 49 fish species and 4,900 known species of higher plants. Uganda's Wildlife Protected Areas include 10 National Parks, 13 Wildlife Reserves, 13 Wildlife Sanctuaries and 5 Community Wildlife Areas. These areas occupy over 25,000 sq. km. Uganda is known among other things, for being home to rare and endangered species such as the Mountain Gorilla, half of the global population being found in Uganda's Bwindi Impenetrable and Mgahinga Gorilla National Parks. Uganda Wildlife Authority (UWA) is in charge of managing the country's network of Wildlife Protected Areas (WPAs).

A number of the WPAs are transboundary in nature, Kidepo being at the tri-border between Uganda, Sudan and Kenya.

2.2. Water resources and water products

Up to 15% of Uganda's total area is covered with water, 80% of which is accounted for by Lake Victoria. In addition, Uganda has a mean annual rainfall ranging from 700 mm in the drier areas to about 1500 mm in the humid areas. The rainfall in good years offsets the water distribution problems particularly during the rainy season. A large proportion of the population depends on streams, which tend to dry up during droughts causing serious water

stress for a large proportion of the rural communities. The scarcity of water in such areas has resulted in movements into neighbouring districts in search for pasture and water. These movements have frequently led to ethnic conflicts and disruption of production, affecting the development of these communities. The water scarcity in the dry land areas is likely to worsen with climate change.

The abundant water resources provide an excellent habitat for fish. Fishery is a key sector in the Ugandan economy, as well as source of food for the population. It contributes to food security, increased household income and economic growth.

2.3. Agriculture

Agriculture is the backbone of Uganda's economy. It constitutes about 42% of GDP, over 90% of export earnings and employs over 80% of the labour force.

The major factors that influence agricultural production include soils, climate, agricultural implements, management practices and access to markets (both domestic and international). The decline in agricultural production in 1999/2000 is partly explained by the 1999/2000 drought. Non-traditional crops such as maize, sesame and soya beans have gained value in the last ten years, which has enabled farmers to make a choice of what type of crop to grow depending on demand, thus improving their incomes. Agricultural performance fluctuates with climate variability and climate change, and is also adversely affected by rudimentary means of production, poor markets and storage facilities.

In Uganda land degradation is predominantly a consequence of agricultural production, which is the main economic activity of rural communities. Subsistence agriculture mines the soil nutrients and causes soil erosion, thus making the land unproductive in the long run. High human populations tend to degrade highland ecosystems, while animals degrade marginal lands such as the cattle corridor, a semi-arid ecosystem, which stretches from Rakai in southern Uganda to Karamoja in the northeast.

The rapid human population growth has led to increased demand for food, energy and other social services. This has led to the expansion of land under agriculture (shifting cultivation) resulting in loss of vegetation.

The expansion of agriculture on previously forested steep terrains has led to soil erosion which has resulted in the silting of rivers and lakes and the loss of water catchment areas.

Soil erosion accounts for over 80% of the annual cost of environmental degradation, representing 4-10% of GNP and estimated at about US\$ 625 million per annum.

The agricultural sector also contributes to pollution through improper disposal of agricultural waste. Huge amounts of fresh, unprocessed foodstuffs (banana, cassava, potatoes, beans and fruits) are transported daily into towns and urban centres where they are processed and consumed. Processing these foodstuffs generates large quantities of agricultural wastes, which invariably are dumped in unplanned sites close to human dwellings. These dumps form mountains of fermenting refuse that produce an unpleasant smell. Severe flooding

experienced in urban centres such as Kampala is a result of poor solid waste disposal and clogs the recently opened Nakivubo Channel.

2.4. Wildlife, mountains and rivers

Global warming is causing retreating of glaciers, particularly in the tropics. In East Africa the ice caps on Mt. Kilimanjaro and Ruwenzori Mountains are retreating. About 82% of the 1912 ice cap on Mt Kilimanjaro has already melted. By 1990, glaciers on the Ruwenzori Mountains had receded to about 40% of their 1955 recorded cover and might disappear altogether within the next 20 years.

The melting of the ice cap on tropical mountains has a negative effect on both the water catchments and eco-tourism, as well as on the overall economy. The melting of ice caps on Ruwenzori Mountains has increased the erosive power of river Semliki (which originates from the melting icecaps). This erosive power and associated siltation downstream, compounded by the intensive cultivation along the river course, has enabled Semliki to disproportionately erode the Ugandan side and literally block its original course. The result is that the course of Semliki River has shifted one almost kilometre into Uganda. There is now an on-going dispute on the actual border between the Democratic Republic of the Congo and Uganda. This is a clear example that climate change is a potential source of regional conflict and war. In addition, the associated cultural loss due to melting of the ice cap is immeasurable.

The mountains provide vital water catchments for humans and wildlife; such changes could drastically affect wildlife species. The Mountain Gorilla, of which half of the world's population is found in Uganda, is also under threat from climate change. The Ruwenzori Mountains are a habitat for important endemic and restricted species that, among other factors, could be there as a result of the unique climate. Among the alpine and sub-alpine species is Giant Lobelia, Tree Senecio (plants), Ruwenzori Leopard and Ruwenzori Red Duiker (or Ruwenzori Black-fronted Duiker (animals). The Ruwenzori Red Duiker, *Cephalophus rubidus*, is a rare and unique duiker subspecies only found in these Mountains.

2.5. Forests

Increased population growth has led to increased deforestation because of increased demand for food and fuel. Firewood provides 95% of Uganda's energy needs. Increased electricity tariffs lead to increased demand for fuel wood and charcoal, leading to increased soil erosion, damage to vital watershed, flooding and silting of rivers and lakes.

Forest products (timber, poles, medicine and firewood) and services (habitat for other diversity, moderating of micro climate, shade and enhancing productivity) play a very important role in the social and economic development of Uganda because of their products (timber, poles, medicine and firewood) and services (habitat for other diversity, moderating of micro climate, shade and enhancing productivity).

3. VULNERABILITY TO CLIMATE CHANGE

Climate change has been manifested in Uganda by, for example, the large number of droughts that have been experienced over the period 1991 to 2000, which was a much higher rate than previously experienced.

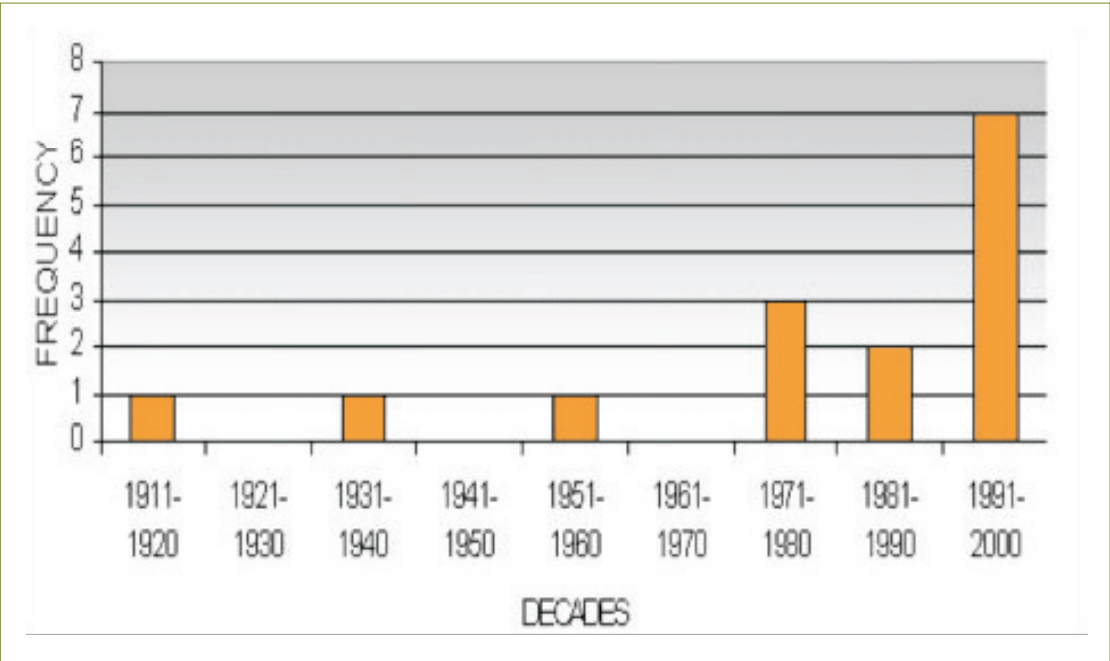


FIGURE 12: Frequency of droughts in Uganda over the period 1911 to 2000.

4. RAINFALL VARIABILITY

Uganda has experienced variations in rainfall patterns leading to floods in some areas while there are droughts in others.

Although the western, central and northern parts of Uganda experienced good rainfall seasons the eastern region experienced drought in 1997. The country experienced above normal rainfall in 1998 (El Niño year), resulting in floods. The floods had serious negative impacts on the health and transport sectors. The flooding of 1998 was followed by severe drought in western region. In 2000, Uganda again experienced widespread drought. The drought was more severe in eastern and northern regions with Arua district being the most affected. However, the western region experienced good seasons. The overall impact of climate variability and climate change can significantly be mitigated through provision of climate information and promoting its utilization so as to take advantage of good seasons in some parts of the country.

THE IMPACT OF KEY ENVIRONMENTAL ISSUES IN ERITREA

1. INTRODUCTION

Eritrea is situated in an arid and semi-arid region of Sahelian Africa. The country has low adaptive capacity relative to constraints in wealth, technology, education, institutions, information, infrastructure and social capital. This renders Eritrea highly vulnerable to climate variability, extreme weather events, and long-term climate change.

With the low lying coastal regions, arid and semi-arid areas, fragile ecosystems, including mountainous ecosystems, and an economy highly dependent on consumption of fossil fuels and associated energy-intensive products, Eritrea is particularly vulnerable to climate change and variability²⁸.

2. GEOGRAPHY OF ERITREA

Eritrea is located in the Horn of Africa and is bordered on the northeast and east by the Red Sea, on the west and northwest by Sudan, on the south by Ethiopia, and on the southeast by Djibouti. The country has a high central plateau that varies from 1,800 to 3,000 meters (5,906 to 9,843 ft.) above sea level. A coastal plain; western lowlands and some 350 islands comprise the remainder of Eritrea's land mass. Eritrea has no year-round rivers.

Eritrea is located in the Horn of Africa between 12° 22' and 18° 02' north and between 36° 26' and 43° 13' east. It is bordering with the Sudan in the west, Ethiopia in the south, Djibouti in the southeast and with the Red Sea in the east.

Eritrea has a total land area of 124,300 km² with a coastline of 1900 km. The Eritrean territorial waters are around 120,000 km², stretching out to the Red Sea Central Rift. There are around 390 islands in the Eritrean Red Sea zone, the prominent being the Dahelak Archipelago.

The population of Eritrea, which is estimated at 3.5 m, is growing between 2.7 and 3 % annually. Population is unevenly distributed, with settlements highly concentrated in the cooler climates of the central highlands.

²⁸. State of Eritrea, Ministry of Land, Water and Environment, Department of Environment: National Adaptation Programmes of Action, April 2007.

3. CLIMATE

Eritrea climate is hot, dry desert strip along Red Sea coast; cooler and wetter in the central highlands (up to 610 mm of rainfall annually); semiarid in the western hills and lowlands; rainfall is heaviest during June–September except in coastal desert. The climate is temperate in the mountains and hot in the lowlands. Asmara, the capital, is about 2,400 m (7,874 ft) above sea level. Maximum temperature is 26°C (78.8°F). The weather is usually sunny and dry, with the short or belg rains occurring February–April and the big or meher rains beginning in late June and ending in mid-September.

Eritrea has diverse climatic zones, mainly due to its high topographic variations. In physiographic terms the country is roughly divided into the Central Highlands (above 2000 m from sea level), the Midlands (1500-2000 m from sea level) and the Lowlands (below 1500 m from sea). The topographic variations have considerable effect on the rainfall pattern of the country. The major rainfall of the Central Highlands and the Western Lowlands takes place during the months of June and September, with much of the rain falling in August. The south-westerly monsoon winds are responsible for the summer rain. The eastern lowland and the escarpments facing these lowlands have rainfall between November and March, which is caused by the northeast continental winds blowing over the Red Sea. Due to orographic effect the escarpments receive high rainfall and since it also gets rain in summer, it is the wettest part of Eritrea. Annual rainfall in Eritrea varies from about 100 mm in the lowlands to about 700 mm in the central highlands, and because of its bi-modal rainfall some places in the escarpment receives more than 700 mm of rain annually²⁹.

Eritrea is an arid and semi-arid country and is not endowed with rich water resources. Being part of Sahelian Africa it has been the victim of recurrent and devastating droughts. It is also a country predominantly dependent on rain fed agriculture. The majority of the population depends on ground water as its main water supply source.

Rainfall in Eritrea is torrential, is of high intensity over a short duration, is very unpredictable and occurs sporadically. Owing to the rugged nature the high lands (highest rainfall areas), thin soil formations, and new largely forested terrain most of the rain develops in to flash floods. Thus soil-water filtration is very low.

In the low lands areas even though there are favourable geological formations, infiltration is also low owing to high evaporation rates and lower intensity rainfall.

Urbanisation is increasing very fast in Eritrea, as is population growth in general. At the same time, land degradation, industrialization, and the consequent negative implication on water recourses, are increasing. Even though water is recycled by the mechanism of hydrologic cycling, the overall picture for Eritrea is that water is in essence a scarce resource. Optimal allocation of this basic necessity is of crucial importance, as the demand for water is increasing across every sector³⁰.

²⁹. State of Eritrea, Ministry of Land, Water and Environment, 2001: Eritrea's Initial National Communication under the UNFCCC.

³⁰. Woldemichael G. Mariam, 2005: Strategic Approach of Rainwater Harvesting using Roof Catchments: the

Deforestation coupled with drought has made the nearest water sources to disappear and thus obliged people to fetch water from distant valleys and riverbed excavations which result into adverse effects of water scarcity through time. It has as well resulted in difficulties of long travel hours up and down from hill top villages in search of few litres of water particularly to women and the young.

The Ministry of Land, Water and Environment of the State of Eritrea is therefore piloting a rainwater harvesting project to increase the number of families harvesting and storing rainwater before it runs off into the seasonal streams.

Eritrea's climate regime is highly variable, being influenced by the expanding Sahel-Saharan desert, the proximity to the Red Sea and the land's physical features. Altitude and topography play major roles in determining climate in general and temperature in particular. Ambient average temperatures vary considerably, with the eastern lowland having an annual mean of 31°C reaching as high as 48°C; while in the highland areas the annual mean is 21°C with a maximum of 25°C. In the western lowland areas, the annual mean is 29°C with a maximum of 36°C.

The whole country is divided into six agro-ecological zones representing two rainfall regimes, summer and winter, whose patterns and amounts are affected by the difference of physiognomic regions. The summer rains are brought by south-westerly monsoon winds and are concentrated mainly in the months of July and August. They affect the central highland and the western lowland areas. The winter rains typically occur from November to March and are influenced by the north-easterly continental winds. These rains affect coastal areas and the eastern and southern escarpments.

Eritrea has a mostly arid climate with about 70% of its land area classified as hot and arid and receiving average annual rainfall of less than 350 mm. The main rainy season in most parts of the country is from June to September. There is also a short rainy season involving a small number of highland areas which occurs between March and May. In the eastern coastal areas and parts of the adjacent escarpment, the rainy season is between December and February.

The eastern lowland has an average annual rainfall between 50 and 200 mm while northern areas, given that they fall within the eastern limit of Sahelian Africa, receive less than 200 mm/year of rain. Southern areas experience average annual precipitation of 600 mm, with the central highland areas receiving about 400-500 mm per year.

A main feature of rainfall patterns in Eritrea is the extreme variability within and between years, and spatial variation over very short distances. The southwest monsoon winds are responsible for the main and small summer rains in Eritrea. The northern and north-eastern continental air streams are responsible for the winter rains along the coast and in southern part of the escarpment of the central highlands. The northern and north-eastern winds are dry in their nature but take moisture while crossing the narrow Red Sea water body.

Over 80% of the population depends on traditional subsistence agriculture, including crop

Eritrean Experience.

production and livestock husbandry. However, agricultural production is affected by a host of factors including high rainfall variability with recurrent and long drought periods, continuous degradation of the soil, frequent pest outbreaks and lack of research and extension services. The poorest people live in the arid highland areas.

4. DEVELOPMENT CHALLENGES AND VULNERABILITY TO CLIMATE VARIABILITY

Small-scale farmers dominate the agricultural sector. Typically, such farmers are living in conditions of persistent poverty and rely on rain-fed and traditional practices. This combination renders them highly vulnerable to climate variability. The eradication of poverty through improved agricultural production is among Eritrea's primary development objectives. Poverty is deeply entrenched in rural areas, home to a majority of the population living on less than US\$1 per day. The depletion of forests – primarily for household fuel use – threatens biological diversity, human communities, and reduces other valuable services forests provide.

5. KEY CLIMATIC HAZARDS

The NAPA identified the following hazards:

- Increased climatic variability: Relative to baseline conditions, there have been observed changes in average, range, and variability of temperature and precipitation throughout the country;
- Recurring drought: The occurrences of dry spells, seasonal droughts and multiyear droughts are more frequent than in the past;
- Flash flooding: there has been a perceived increase in episodes of torrential rainfall with heavy runoff and flooding; and
- Sea level rise: Coastal areas and the hundreds of Eritrean islands in the Red Sea are susceptible to rising sea levels associated with climate change.

6. IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON ERITREA

6.1. Climate change impact on agriculture

Eritrea has only modest land resources for rain-fed agriculture. The little rain that usually fell during the April/May season has all but disappeared. In recent years, the main rainy season starts later and finishes earlier than the historical pattern resulting in some wheat and millet varieties, as well as some native cultivars, disappearing from production, due to recurring rain-fed crop failures. New crops pests are appearing that have been previously unknown or uncommon. Irrigated crops are also adversely affected due to depletion and drying of water wells on which irrigation depends, as well as unusually heavy flooding during the rainy season. These circumstances are increasing the heavy toll on subsistence farmers.

6.2. Climate change impact on livestock

Frequent droughts between 1992 and 2004 have led to the deaths of thousands of cattle and camels. In addition, thermal stress is increasingly exceeding thresholds that animals can tolerate, leading to decreased feed intake, interference with animal productive and reproductive functions, requiring a shortening of grazing hours, and increasing exposure to pathogens. Pastoralists in the eastern lowlands and north-western rangelands are the most vulnerable to these patterns.

6.3. Climate change impacts on forestry

Most of Eritrea's land areas are characterized by sparse to medium coverage of shrubs with almost not areas covered with trees. Climate variability impacts soil moisture and adversely affects the growth of shrubs and trees. As temperature increases, there are increasing shortages of biomass both for energy and local house construction, as well as declines of biomass products such as frankincense, gum Arabic, doum palm leaves, wild fruit, wild medicine and fodder. The most vulnerable species are those shallow rooted with narrow temperature tolerance including *Dodonaea angustifolia*, *Psiadia punctulata*, *Meriandra bengalensis* and *Otostegia integrifolia* in the eastern and western escarpments of the country and those with slow growing habits such as *Olea africana* and *Juniperus procera*.

6.4. Impact of climate change on water resources

Eritrea has an extensive river system with seasonal flow patterns. However, recurrent drought, warmer temperature and high evaporation patterns are resulting in smaller stream flows, lower groundwater level, deterioration in water quality, and disappearance of base flows which are the sources of water supply for urban, rural, livestock and industry.

All towns located in the upper part of the major drainage basins (Mendefera and Dekemehare) or at the water shade dividing ridges (Adikeyih and Barentu) are particularly vulnerable. On the other hand, most of the coastal villages are located within less than 15 km distance from the sea. Fresh and scarce groundwater is found mostly underneath the larger ephemeral rivers and is extracted using very shallow open wells.

Because of these sources proximity to the sea and its arid climate, the coastal village's water supplies are very sensitive to salt-water intrusion and flooding.

6.5. Climate change impact on the coastal and marine environment

The distress of coral reefs in the Red Sea as a result of temperature rise has had a devastating effect both on Eritrean fisheries as well as the reefs themselves. Temperature changes affect through impacts on food and nutrient supply, growth, survival, reproduction, prey-predator dynamics and habitat. Similarly, temperature increase causes toxic algal blooms (such as red tide) that threaten the shellfish population through lethal and chronic impacts. Climate change is likely impacting mangroves and sea grasses through altered sediment budgets.

6.6. Impact of climate change on public health

Malaria has now been observed at altitudes close to 2,000 metres in Eritrea, a new phenomenon that is attributed to climate change. Increasing climate variability will exacerbate food security and lead to malnutrition, impaired child development and decreased adult activity. Also, diarrhea is being manifested from flooding and drought events. During floods, the spread of infective micro-organisms and parasites increase contamination particularly of waste. During drought, water supply is decreased creating difficulties in maintaining hygiene.

7. STRATEGIES FOR COPING WITH CLIMATE CHANGE AND VARIABILITY

7.1. Key strategies

The NAPA for Eritrea was established within the national initiatives such as the Poverty Reduction Strategy, the National Environmental Management Plan (NEMP), Eritrean Initial National Communication, Multilateral Environmental Agreements (MEAs), United Nations Development Assistance Framework (UNDAF), disaster preparedness and prevention strategies, and various sectoral ongoing and formulated projects and policies.

Moreover, the NAPA process in Eritrea has been actively seeking to identify ways to mainstream adaptation to climate change into national development processes, by inclusion of climate and vulnerability in sectoral and development policies that are complementary to climate change. In particular, there are several national policy processes that have parallel aims to climate change adaptation have been the focus of scrutiny.

The key coping national strategies include:

- Poverty reduction strategy
- Environment Management Plan
- Initial National Communications to the UNFCCC
- National Capacity Self-Assessment which identified key capacity constraints for the implementation of environment programs.
- Sustainable Development Summit
- Development Assistance Framework
- Multilateral Environmental Agreements – Eritrea has signed up to join UNCBD, UNCCD and UNFCCC among others.

7.2. Barriers to the implementation of the napa

Eritrea faces numerous challenges and barriers when it comes to the implementation of urgent and immediate activities identified by the NAPA process. Some of the major barriers that will need to be overcome can be summarized as follows:

- *Institutional Organization*: Institutional coordination is lacking in the implementation

of development projects and Multilateral Environmental Agreements (MEA). Due to the lack of a clear and transparent legal framework, institutional organization is sometimes inappropriate and has overlapping mandates and responsibilities that create conflicts of interest among stakeholders;

- *Capacity*: There is a chronic shortage of human resources and skills essential for the implementation of potential adaptation initiatives³¹. This is recognised as one of the most critical constraints to the implementation of the NAPA.

- *Policy gaps*: While Eritrea has macro policies in place, there is a lack of regional and/or micro policies for the various socioeconomic sectors. Where regional/macro policies are in place, they suffer from important gaps that inhibit effective action toward sustainable development. There is also a lack of regulatory mechanisms for existing legislation and sectoral policy. Lack of approved laws and regulations that are directly linked with climate change and variability like environmental law, water law, and maritime code have not being approved.

- *Lack of clear institutional mandates*: There is no clear mandate and responsibility among institutions as a result there is duplication and overlap of activities; and

- *Funding*: There is concern that inadequate funding both at the national and international levels may limit the level of implementation of all measures identified in the Eritrea NAPA.

8. ERITREA BIODIVERSITY STRATEGY AND ACTION PLAN

8.1. Background to the strategy

The aim of the Eritrea Biodiversity Strategy and Action Plan is to help reverse the severe environmental degradation that was occasioned in Eritrea during the up to the time of its independence, where most of the resources exploited were terrestrial while the coastal and marine resources remained largely unexploited³². Implementation of this strategy is expected to help reverse the trends in environmental degradation, habitat loss and reduction in wildlife in the country.

An important principle of the strategy is that the most appropriate niche for biodiversity-related activities in Eritrea lies within the existing policy framework for sustainable economic development. The NBSAP attempts to place biodiversity policy in the context of the government's major development objectives over five years. The NBSAP seeks to integrate and co-ordinate these activities to increase their effectiveness for biodiversity conservation, rather than replace or add to them. Biodiversity-related activities must be made compatible with those designed to improve human welfare in Eritrea. Fortunately, there are many situations where these two goals are complementary and even self-reinforcing. The NBSAP focuses on these «win-win» opportunities, plus those interventions which are considered to be essential to meeting the obligations to which Eritrea has committed itself to undertake the Convention on Biological Diversity.

³¹. See the detailed analysis in State of Eritrea, National Capacity Self-Assessment, December 2006.

³². State of Eritrea, Department of Environment, Ministry of Land, Water and Environment, 2000: National Biodiversity Strategy and Action Plan.

8.2. Accession to complementary international conventions

The State of Eritrea formally acceded to the Convention on Biological Diversity (CBD) on 21st March 1996. Eritrea has been a participant at recent meetings of the Conference of Parties (COP) and supports international community attempts to reverse the overall global decline of biological diversity through the activities of the CBD.

In 1996, the Eritrean Environmental Agency (EEA) was named as the government institution responsible for co-ordinating Eritrea's activities under the Convention. In 1997, the EEA was restructured as the Department of Environment (DOE) in the newly created Ministry of Land, Water and Environment (MLWE) of the State of Eritrea. The DoE has assumed responsibility for co-ordination of CBD-related activities within Eritrea, although biodiversity-related activities are implemented by a wider range of government and public agencies.

9. STATUS OF BIODIVERSITY IN ERITREA

The biodiversity of Eritrea may be described conveniently under three core areas:

- The natural terrestrial habitats characteristic of the region;
- The diverse agro-ecosystems which have developed as a result of traditional agricultural activities in the region; and
- The coastal marine and island ecosystems of the Red Sea.

The status of the three core areas is not known precisely at present (2000)³³.

The growing human influence, amplified by war and drought has placed increasing pressure on the natural terrestrial biodiversity of the country. Similarly, the agro-biodiversity associated with indigenous, traditional farming systems has been disrupted severely by the same forces. By contrast, the marine ecosystems of the Eritrean Red Sea region have been much less affected by these pressures and are ecologically relatively intact.

Although the long-term trend in biodiversity status in Eritrea over the past century has been negative, between 1991 and 1998, the overall status of wild terrestrial biodiversity in Eritrea has improved, albeit from rather poor initial conditions. This improvement has resulted from the cessation of armed conflict and a sequence of relatively good years of rainfall. This period of stability has allowed both natural habitat and agricultural systems to recover from their degraded state. The period of relative stability and good rainfall has also contributed to the success of efforts to intensify agricultural production, increasing the (man-made) threat to some agro-biodiversity. In the marine sector, the increase in economic activity has proceeded fairly slowly and threats to marine biodiversity are still relatively localised (e.g. pollution impacts around Massawa and Asseb).

10. STATUS OF ACHIEVEMENT OF ENVIRONMENTAL SUSTAINABILITY IN ERITREA (MDG 7)

The State of Eritrea prepared its first MDGs achievement report in 2010. It shows that

³³ State of Eritrea, *ibid.*

although sustainable development initiatives have been integrated into the country's policies and programs, the reversal or even halting of environmental degradation is still not achieved. Achievement of Goal 7, Ensure Environmental Sustainability, is therefore a key strategy for the State of Eritrea in combating environmental degradation.

The main constraints are³⁴:

- Weak enforcement – the Ministry of Lands, Water and Environment is ill equipped to enforce the rules and regulations.
- Lack of appropriate technologies, building materials and sustainable maintenance systems – these factors have hampered the provision of safe drinking water and shelter.
- Land access issues – all land in Eritrea is vested in the Government. Allocation procedures have not been fully worked out. This hampers access to land for housing, especially low income housing in the urban areas which contributes to overcrowding in homes.
- Scarcity of alternative energy sources – for lack of alternatives, firewood remains the predominant form of energy, resulting in intense pressure on an already fragile environment.

Opportunities for reversing the loss of environmental resources and improving the lives of slum dwellers include:

- Alternative energy sources – ways have to be found to replace firewood with alternative sources of energy, including electricity, gas, wind and solar energy.
- Affordable housing: increasing access to affordable housing with water and sanitation for the poor would relieve slum conditions in urban areas and reduce poverty.

11. GREENHOUSE GASES

11.1. Emissions

Eritrea, being a young developing economy, emits minimal amounts of GHG such as carbon dioxide, methane and nitrous oxide, mainly from the agriculture and energy (especially fossil fuel combustion) sectors.

Greenhouse gas (GHG) mitigation is not a priority for Eritrea, as it is still in its early stage of developing its economy. In the fulfillment of its commitment under the Convention Eritrea's main strategy is therefore adaptation rather than pursuing mitigation options.

11.2. Adaptation measures

- Strengthening further reforestation/afforestation programs, aiming at rehabilitating degraded lands and at the same time solving critical timber and fuel wood supply, as appropriate.
- Expand further the use of closure area system for the regeneration of natural

³⁴. State of Eritrea, 2005: Millennium Development Goals Report.

vegetation.

- Strengthen the conservation of natural forest and introduce proper forest management practices, including the establishment of forest reserve areas.
- The introduction and use of energy efficient technologies in the generation of electricity. The Hirghigo Power Plant Project is a good example in this context.
- Introduction of energy efficient devices in cooking, cooling and lighting. These may include the introduction of efficient wood stoves in cooking, introduction of solar cooling devices and increasing lighting efficiency through the use of fluorescent in place of incandescent lamps.
- The development and expansion of renewable energy supply technologies. In this respect many solar PV systems with an average capacity of over 400 kW have been installed in the rural areas.
- The expansion of the use of liquid petroleum gas (LPG) and kerosene. Currently there is an on-going program to increase the supply of kerosene and LPG to rural areas and these needs to be strengthened further in the future.
- Formulations of new energy laws, regulations and standards so as to reform and deregulate the energy sector in order to encourage competition and efficiency.
- Introduction of efficient public transport system, particularly in urban centres.
- Introduction of regulatory frames that would ban old cars and also encourage the introduction of efficient vehicles using catalysers and the provision of good quality roads and proper traffic planning³⁵.

12. ASSESSMENT OF VULNERABILITY TO CLIMATE CHANGE AND VARIATION

By virtue of its geographical location and also because of its least adaptive capacities, Eritrea is one of the most vulnerable countries of the world to the adverse effects of climate. Due to the changing and unpredictable patterns of precipitation, for example, agricultural production, which is the main economic stay of the country, was severely affected in the past. The assessment of vulnerability and adaptation to climate change is somewhat a complex undertaking but, nonetheless, efforts were made to predict some changes of climate using global circulation models.

Climate change models predict an increase of temperature and the range between the monthly mean will vary from 29-37°C, 28-37°C and 18-26°C in the coastal plains, the western lowland and in the central highlands respectively. The increase of temperature due to doubling of GHG concentrations across the country is expected to rise by 4.1°C, well within the IPCC's globally predicted range, i.e. 1.5 to 4.4°C for effective doubling of CO₂ over the next century. On the other hand precipitation is expected to vary by a ratio of 0.1 to 0.15.

12.1. Agriculture

Over 80% of Eritrea's population depend for their livelihood on traditional subsistence

³⁵ State of Eritrea, 2001, ibid.

agriculture, including crop production and livestock husbandry. Eritrea's high variation of climate and topography create favourable conditions for the growth of different cultivated crop plants. Agricultural production, however, is affected by a host of factors including high rainfall variability with recurrent and long drought periods, continuous degradation of the soil, frequent pest outbreaks and lack of research and extension services.

Land is almost the sole source of income for a majority of the Eritrean population and its degradation is a serious problem. The annual net soil loss from croplands is estimated at 12 tons/ha, and agricultural production under rain-fed conditions could hardly be determined in any event. Such factors have caused productivity to be less than 0.7 tons/ha for many crops. It is estimated that 16% of the total land area is arable of which only a quarter is actually cultivated. Agriculture on the average accounted for about 19% of the GDP for the period 1992-1997, suggesting both its undeveloped nature and its low productivity.

In order to increase the role of the agricultural sector in the growth and development of the country, the idea is to intensify agricultural production in areas of good soil and with reasonable rainfall. Moreover, there are opportunities to construct bigger dams for irrigation purposes in strategic locations but due to technical and financial limitations it was not possible to implement such undertakings. Furthermore, there are also plans to modernize the agricultural sector, through the development of irrigated agriculture, by utilizing underground water resources. Nonetheless, caution should always be exercised in the exploitation of ground water resources, as this capacity is not known accurately. There are clear indications that some wells used for irrigation purposes are getting saline or getting depleted due to over exploitation. Given the long period of time required to replenish ground water, caution is called for planning ambitious irrigation projects.

12.2. Marine and coastal resources

The marine and coastal resources, particularly fisheries, are recognized as one of the very important areas, which could have a very crucial role in the economic development of the country. Having 1900 km of coastline, Eritrea has a very high potential not only to exploit its fish and other marine resources but also has an excellent opportunity to develop its tourist industry. The Eritrean Red Sea and coastal beaches remain relatively pristine due to lack of pressure from fishing, tourism and coastal or offshore industrial development.

The Eritrean Red Sea zone has many endemic marine and coastal species; the conservation of marine and coastal biodiversity for a sustainable use poses a challenge not only for Eritrea but also to the international community. There are about 500 fish and 44 genera of hard corals recorded by recent surveys, and the Eritrean coast is inhabited by up to 5 marine turtles, 8 or more cetaceans and the dugong – almost all of these species are of conservation concern globally. The level of endemism for fish as a whole are around 18%, but extend to more than 50% for some fish groups (e.g. butterfly fish). Mangrove trees are also important coastal plants, which contribute to the maintenance of coastal ecology in many ways, including the protection against wave erosion and the provision of organic matter for soil formation and act as a wildlife habitat and nursery for many marine species. Timber extraction for various purposes, like fuel wood, construction of boats and over browsing by camels have been the main causes of mangrove degradation.

12.3. Energy

The energy balance for Eritrea is dominated by the use of biomass fuels; by 1996, 77% of the Total Final Energy Supply was covered from biomass, 21.3 % from oil products (primarily petroleum) and 1.4% from electricity. The constituents of biomass were firewood, charcoal, dung, and agricultural residue, accounting for 76%, 11.6%, 10.4% and 2% respectively.

Heavy reliance of the country on fuel wood for cooking increases the degradation of forests and wooded lots. This coupled with the significant population growth and the fact that 80% of the population live in the rural areas makes the vulnerability of the rural population high.

12.4. Vulnerability assessment in the forestry sector

Only approx. 2.4% of Eritrea may be categorised as forest owing to widespread environmental degradation over the past few decades. The conversion of forests and woodlands into agriculture, firewood collection and overgrazing exacerbated the situation. El Niño related droughts of the early 1970s, 1982-85, and in the 1990s have also caused massive plant losses.

Biodiversity has suffered in the hands of past generations. Plant communities have been greatly altered with impoverishment of local species. Wildlife has been devastated through loss of habitat and hunting. The remaining 'closed', 'medium closed' and 'open' forests are restricted to the eastern escarpment and in some river basins. Despite the continuous destruction of forest, however, Eritrea has a rich floristic composition owing to the diversified climatic conditions and differences in altitude and soil, which need to be protected.

The effects of deforestation are evident. There is shortage of construction poles and fuel-wood supply in the country. Deforestation on steep lands has increased the sediment loads of rivers, reservoirs and canals. Exposed soils, particularly following mechanical clearing, are subject to erosion, compaction and crusting.

The low occurring natural forests still remain very important resource to rural communities by providing fuel wood, construction materials, medicines, forage and shelter. However, despite various efforts at conservation, the destruction of this natural vegetation continues unabated.

13. MITIGATION AND ADAPTATION OPTIONS

13.1. Mitigation and adaptation options in the forestry sector

Land degradation including deforestation, loss of biodiversity and habitat loss still remain the most serious environmental problems in the country. The scale of impact of land degradation on the social and economic wellbeing on the Eritrean population is incalculable. Since the majority of the Eritrean population depends on biomass fuel as source of energy, shortage of fuel wood, for example, is one of the most visible problems. For enhancing sustainable

agricultural production, while at the same time solving critical environmental problems of land degradation, the following options are being pursued by Eritrea:

1. Afforestation: Afforestation activities in deforested lands constitute a very important element in the overall national programs and activities of relevant government institutions, such as the Ministry of Agriculture, the Ministry of Local Government and the Ministry of Land Water and Environment. Since 1991, more than 56 million seedlings of different species have been planted in deforested lands, covering an area of more than 16,000 ha of land. The major problem encountered in tree planting is lack of rainfall, which greatly affects the tree survival rate and establishment of newly planted tree seedlings. The emphasis of tree planting is now based on indigenous tree species rather than on exotic species, as was the case in the past with eucalyptus species.

2. Soil and Water Conservation Activities: Deforestation, burning of grassland, rampant soil and water erosion, are leading to ecological degradation and habitat loss. This phenomenon drastically affects the soils capacity to store carbon, and in effect undermining sustainable agricultural production. The overriding objectives of the country, i.e. the achievement of food security and poverty reduction could not be achieved unless the problem of land degradation is solved. Cognizant of this fact the Government is making considerable efforts to mobilize its meager resources to tackle this problem. In this connection, high school students have regularly been mobilized to undertake terracing activities during summer since 1994. Under this program more than 75,772 km of terraces have been built for soil and water conservation purposes. These include cropland and hillside terracing.

3. Expansion of Closure System: Although a closure system is a traditional way of land recovery, it is now widely practiced in the country as a means of fighting land degradation. The closure system is usually divided into temporary and permanent closures. The traditional temporary closure system is practiced by many villages in the central highlands for preserving grass for their cattle during the dry season. In the permanent type of closure, land is delineated and is excluded from any human or animal activities for an extended period of years, usually more than 10 years, for allowing the regeneration of natural vegetation. This system has proven to be not only cost effective but also is very productive in terms of restoring degraded ecosystems.

Currently there are more than 200,000 ha of land brought under the closure system. In many closure areas it is encouraging to see the re growth of natural vegetation and the coming back of some wildlife species, which were believed to be lost forever.

4. Protection of Existing Natural Forest: Eritrea's remaining thick forest area is mainly located in the Eastern Escarpment overlooking the coastal plains of the country. This area gets bimodal rainfall, i.e. June to September and November to March. Moreover, there are riverine and mangrove forests, which are under threat of deforestation for agricultural expansion. Eritrea's current forest area is estimated to constitute only about 2.4% of the total land area of the country. To protect the remaining forests, efforts are being made to develop management plans. Thus far «The Management Plan of Riverine Forest of the Western Lowland» has been prepared and efforts are being made to develop a forest management plan for the «Green Belt Integrated and Sustainable Forest

Resource Management». Capacity limitations, including financial and legal, remain one of the major bottlenecks to prepare and implement such management plans.

13.2. Mitigation and adaptation options in the energy sector

1. Increasing Energy Efficiency: The Eritrean Electric Authority has made considerable progress in its efforts to increase the electricity generation capacity. It has increased the capacity from 35 MW in 1991 to over 70 MW by the end of 1996. With the commissioning of the Hirgigo Power Supply Project the capacity has been boosted by a further 84 MW by the end of 2001. The new generation facility is to consume around 170 grams of heavy fuel oil per kWh of electricity generated as compared to the average consumption of around 220 grams of diesel or light fuel oil. If we estimate the generation for 2002 to be around 300 GWh, the new generation facility will reduce CO₂ emissions by around 45,000 tonnes in that year.

To make the power systems more efficient and to promote energy conservation measures, feasibility studies of major projects to rehabilitate the old transmission and distribution systems in Asmara and Massawa have been finalized. The Massawa project is being implemented. When finalized, the current technical losses of 20% in transmission and distribution system will be reduced by at least 50%. Assuming that oil fired stations produce about 0.7 ton of CO₂/MWh generated, this reduction in technical losses implies CO₂ abatement of 21,000 tons/year.

2. Increasing Efficiency of Traditional Stoves: To tackle the prevalent household energy problems, a program to disseminate improved traditional wood-stoves has been launched and the supply and distribution of kerosene and LPG has been expanded. The improved stoves have around 21% efficiency as demonstrated experimentally, while the traditional stoves are less than 10% efficient. Simple calculations made suggest that the CO₂ reduction potential per improved stove is 0.6 million tons per year.

13.3. Use of renewable energy sources

The renewable energy sources being considered and being implemented in various parts of the country include:

- Wind energy – a study had been conducted for the southern coastal areas of Eritrea. However, no update of the study was available at the time of writing this report.
- Solar photovoltaic systems – these are being installed in various parts of the country including 25 for health centers, 60 water pumps, 70 school lights and power supply, general communication purposes, light houses and powering remote offices.

13.4. Mitigation and adaptation options in the transport sector

In the Eritrean context the transport sector constitutes a major source of CO₂ emissions, accounting for 41% from fossil fuel combustion in 1994.

The Eritrean taxation policy gives due emphasis to the public transport sector. Public buses,

for example are imported with a minimal tax, and the use of non-motorized transport system, such as bicycles, is encouraged. Roads in bigger cities, such as Asmara, for example, are being constructed taking into account bicycles. To further strengthen its policies on land transport the Government in 2000 issued a Land Transport Proclamation No.111/2000, whose objectives are the development and establishment of the land transport system in the country with adequate standards and safety requirements.

Development of mitigation policies and measures over the long-term period in the transport sector may include the following:

- Introduction of efficient public transport sector system, particularly in urban areas.
- Introduction of efficient vehicles using catalyzers and the provision of good quality roads and proper traffic planning.
- Introduction of regulatory frames that would ban old and outdated cars.
- Encourage the use of non-motorized transport systems, such as bicycles.
- Introduction of proper urban planning mechanisms.

13.5. Mitigation and adaptation options for the water sector

Given the fact that water has always a scarce natural resource, farming communities have tried to develop coping mechanisms to deal with shortage of water, including for agricultural and domestic purposes. Such mechanisms include the construction of terraces for soil and water conservation and the construction of small earthen dams. Moreover, farmers over the generations have always tried to develop drought resistant varieties (crops and animals) to cope up with cyclic drought conditions. These adaptive strategies, which the farming communities have developed in the past, are still being pursued and developed using modern knowledge and techniques. In this respect the following adaptations options are quite important to resolve and mitigate water shortage problems that may exist in the country.

- The construction of dams and check-dams has been one of the major engagements of the Government since independence in 1991. Between 1992 and 1999 more than 75 concrete and earthen dams were constructed. More than 1000 km long check-dams were also constructed to protect these dams from silt accumulation. These dams vary in water holding capacities from 0.3 million m³ to 0.5 million m³. Many of these dams are being used for small-scale vegetable production. The construction of dams is equally important in the Gash-Barka basin if sustainable human settlement and agricultural production is to take place.
- Undertake assessment studies of the underground water potential of Eritrea, including water irrigation potential of the major river basins, including that of Gash-Barka River basin (a transboundary basin).
- Establish and strengthen a national meteorological and hydrological information system.
- Develop a national disaster management strategy to mitigate the adverse impacts of

periodic droughts. The early warning systems should be coordinated by the Ministry of Land Water and Environment, the Ministry of Agriculture, the Ministry of Transport and Communications, the Ministry of Fisheries, etc.

■ The current water management practices are not commensurate with the existing water shortage of the country. Water tariff is only practiced in major cities, and there is no progressive water tariff charge in use. Moreover, there is no policy to levy tariff on irrigation water. The absence of such policy measures allows investors to exploit and consume lavishly too much water. Such uncontrolled exploitation of scarce water resources not only depletes scarce water resources, but also leads to salinity hazards. Uncontrolled exploitation of underground water resources, for example, exists in the Gash-Barka region and there are clear indications that underground water resources are getting saline and hence becoming unproductive for irrigation purposes. It is therefore timely that cost effective water management policies, including pricing policy, be introduced as early as possible. Moreover a national water law must be put in place to regulate and manage the sustainable use of water resources.

14. POLICY MEASURES IN THE CONTEXT OF CLIMATE CHANGE AND VARIABILITY

14.1. Poverty reduction

Economic development and poverty reduction remain the central goal of the Government of Eritrea, as enshrined in the Constitution, through a strategy initially articulated in its Macro-Policy Paper of 1994 and also in its National Economic Policy Framework and Program presented in 1998. One of the main elements of this strategy is the investment in rural infrastructure, the development of agriculture and fisheries and the proper management of natural resources, including management of pastures and animal resources and the protection of the environment.

In the second half of 2001 Eritrea has also come up with the “Transitional Economic Growth and Poverty Reduction Strategy”, covering the period 2001-2005. The Strategy follows a two-pronged approach in its effort to achieve economic growth and poverty reduction. Firstly, for the immediate period 2001-2002 two of the main challenges are to address the immediate needs for humanitarian assistance and the restoration of a stable macroeconomic framework.

Secondly, for the medium-term period 2003-2005 the emphasis, among others, will be the development of new export markets, increasing agricultural productivity, achievement of macroeconomic stability and the development of sound financial system.

14.2. Environmental policy and institutional measures

Environmental issues constitute a major part of the Macro-Policy Paper of 1994 and a special chapter is devoted to providing policy guidance to environmental protection, including policy guidance on the introduction and development of impact assessment, the conservation of biological resources and the prevention of pollution from wastes. The Eritrean Constitution

has also emphasized, in the interest of present and future generations, the need for ensuring the management of natural resources in a balanced and sustainable manner.

The government has prepared the National Environmental Plan for Eritrea. The Eritrean Environmental Agency, as an autonomous department under the Ministry of Land, Water and Environment, is the Lead Environmental Agency of the State. It is entrusted with the development and elaboration of national policies, programs and strategies on the environment. The proper conservation and utilization of environmental resources cannot be achieved by the activities of one government institution alone, as the issue is complex and vast in scope. Various line ministries and other government institutions address environmental management issues within their portfolios. For example the Ministry of Agriculture addresses environmental issues related to agricultural activities and the Ministry of Trade and Industry addresses issues specific to trade and industry, etc. The Department of Environment therefore plays a coordinating role among the various institutions, including the NGOs.

THE IMPACT OF KEY ENVIRONMENTAL ISSUES ON SOMALIA

1. INTRODUCTION

The greater parts of Somalia are arid and semiarid with only seasonal rivers and streams and groundwater being the main sources of water. Large scale environmental degradation has exacerbated the already dire situation with widespread deforestation in search of wood for charcoal.

The average rainfall in Somalia is around 250 mm per year yet the potential evaporation is around 2,000 mm per year. Droughts have therefore hit the country over the last few decades. It leads to water shortage and starvation particularly for the rural communities, which are more dependent on rainwater and grass for their survival in livestock rearing and cultivation traditions. Being a natural disaster, drought causes loss of life both human and animal every year in Somalia. Deadly droughts are often followed by devastating floods, another natural disaster, which mainly severely affects the southern part of the country, where the two rivers, the Juba and the Shabelle, flow. These recurrent droughts and severe floods affect the lives of the people and their animals without prediction and prevention.

Somalia is a country that has been in turmoil for the last 25 years ever since the collapse of central government in 1991. There is a severe lack of baseline data for policy making and planning in the country in general and in South/Central in particular. Over the past 25 years neither national population census nor national demography and household income and expenditures survey were conducted due to political situation prevailing in the country³⁶.

Under Goal 7 of the MDGs, Somalia is expected to ensure environmental sustainability within its borders. As mentioned in the MDGs report, Puntland and Somaliland are doing much better in the achievement of the MDGS than the South/Central areas where the Transitional Federal Government (TFG) is ruling.

2. HUMAN CREATED PROBLEMS

Human-induced environmental abuses include: water pollution contributing to human health problems; alarming deforestation and overgrazing resulting in desertification and soil erosion; salinisation by inefficient irrigation systems thus destroying valuable productive land; illegal fishing and industrial toxic waste dumping in the sea and coastline areas by outsiders;

³⁶. Transitional Federal Government of Somalia, 2010: Millennium Development Goals Progress Report.

improper disposal of human and solid waste by local people affecting the public health; hunting and extinction of wildlife; and degradation of coastal zones. Increasing population living along the coastline put significant pressures on coastal aquifers for freshwater supply. Vast marine resources are under unprecedented threat from overexploitation of fish resources and hazardous waste dumping activities by outsiders.

The main environmental problems of Somalia are given as³⁷:

- The rate of deforestation in many areas of Somali territories is increasingly reportedly alarming.
- The amount of industrial toxic waste repeatedly illegally dumped in Somali seawater and the mainland is scaring.
- Quantity and quality of freshwater resources needed for human and animal consumption, as well as for food production, are lacking.
- Amount of pollution entering into the groundwater from urban centres and affecting human health are increasingly growing with no actions taken to minimise and stop.
- Devastating droughts and destroying floods, affecting everyone in the country, are inevitably recurrent without prediction and prevention.
- Magnitude of water and environmental crisis now facing Somali, on the eve of the 21st century, is unprecedented.
- In its totality, damage done to Somali's environment is unimaginable and it seems unmanageable even long after a solution is found for the current political crisis.

3. CLIMATE OF SOMALIA

The climate of Somalia is determined by the north and south movement of the inter-Tropical Convergence Zone (ITCZ). In most areas of Somalia this results in two rainfall seasons - the Gu as the zone passes northwards and the Deyr as it moves south. In both cases, rain is produced from the moist air derived from the Indian Ocean, in the southerly air stream. The north-easterly winds, emanating from Asia and Arabia, produce little significant rain. Variation from season to season and variations within the season are what determine the successes of agricultural activities.

The movement of the ITCZ also causes distinct changes in the wind direction throughout the year. When the ITCZ is to the south, the winds are from the northeast and when it is to the north the winds are from the southwest. This 180° shift to the southwest occurs gradually as the ITCZ passes over, spanning approximately between March-July, and then returning to the north-east winds by December. While there are some regional variations, this pattern is dominant across the whole country. Sea breeze can be significant and cause strong southwest winds off the north coast during June-August that are locally known as kharif.

Wind speeds average between 0.5 - 10 m/s, with the highest wind speeds occurring in the

³⁷ Somali Centre for Water and Environment found at <http://www.somwe.com/problems.html>.

Northern Plateau. While the strongest winds occur between June and August, the weakest winds generally occur as the ITCZ passes over the Equator in April to May in southern Somalia³⁸.

Mean temperatures in Somalia are hover around 30°C, with a temperature lapse of 6.5°C per 1,000 m. The highest temperatures occur around Luuq in the Gedo region near the border with Ethiopia.

There are few records of evaporation and the values which have been reported in various studies to vary between about 1000-3000 mm/yr. In general, evaporation is greater than precipitation across the country but there are localised areas in southern Somalia, around Jilib and Baidoa, where for a few months of the year higher rainfall than evaporation may be experienced. This occurs at the beginning of both the Gu (major wet) and Deyr (minor wet) seasons, thus allowing crop growth to commence. Total evaporation generally increases from south to north, with the highest annual evaporation occurring on the north coast. The time of greatest evaporation also varies across the country, being the middle of the year in the north, and the beginning of the year in south and central regions. However, the contrast is great in the north with only minor changes in evaporation throughout the year in the south. Based on the average annual rainfall pattern, the country has a desert to dry sub-humid climate.

The rainfall observation network in Somalia is quite poor, as shown in Figure 5; some regions do not have any rainfall observation station.

4. ENVIRONMENTAL BACKGROUND OF SOMALIA

4.1. Forest cover

Somalia's forest cover has been reduced in the last few years and natural forest regeneration is slow due to the arid climate. Specifically, the cutting down of acacia trees for charcoal production has had a detrimental impact on the sustainability of the pastoralist livelihood but the activity is likely to continue as long as an alternative source of energy for cooking is not found and individuals economically engaged in charcoal. The proportion of land area covered by forest declined from 12% in 2000 to 11.4% in 2005.

Since 1991, Somalia has been subjected to extreme environmental degradation both natural and manmade associated with the current war and lawlessness. The affected areas included Lower and Middle Shabelle, Lower Juba, Bay, Bakool and Puntland. Other areas can be identified through closer inquiry.

There is a growing danger of deterioration of the environment and personal health. The economic crisis, high population pressure, competition over limited resources and poverty are root causes leading to hundreds of thousands of Somali people destroying the fragile ecosystems and misusing resources they depend upon for their survival and well-being.

Among other things, the challenges facing Somalia today are growing deterioration of forest

³⁸. Muchiri P.W. (2007), Climate of Somalia. Technical Report No W-01, FAO-SWALIM, Nairobi, Kenya.

4.2. Mangrove swamps

One of the major ecosystems in Somalia includes mangroves, which have high productivity levels as they receive nutrients from both sea and land. Mangrove forests are home to a rich assortment of wildlife, such as birds and many aquatic species, but they also are natural buffers that shelter coastal communities and wildlife from the brunt of storms and waves, such as tsunamis. The patches of mangroves in Somalia play a vital role in reducing shoreline erosion. Also, mangroves perform several other ecological and hydrological functions including water supply, erosion protection and habitats for fish. They are critical for the conservation of biological diversity. The mangrove patches are now heavily degraded owing to overexploitation for firewood and construction purposes, which leads to more sedimentation and excessive nutrient loads. Somalia depends principally on domestic wood and charcoal to meet its household energy needs.

Some areas have been destroyed with clearing so extreme that no large areas of vegetation have survived, leaving the land barren. The function of the mangroves as coastal buffers and the effects of their removal along the coastline may have exacerbated the impacts of the aftermath of the tsunami. The deposits of silt could clog the pores of the aerial roots of mangroves and suffocate them.

The heavy dependence on wood for firewood and building materials with an increase in charcoal exports to the Middle East has contributed to the destruction of the forests, woodlands, mangroves and the entire natural habitat in Somalia. Currently, there are very limited alternative energy sources.

Oil pollution could also be one of the threats to the mangroves as there are tanker lanes along the Somalia coast linking the Gulf to the Atlantic Ocean. In its ports, Somalia lacks the basic facilities for handling bilge, and small oil spills are common.

Overall, the regenerative capacity of the mangrove systems may have declined considerably and the ability to provide fishing grounds for fish, molluscs and crustaceans could have dramatically decreased as a result of uncontrolled harvesting. However, an assessment of the extent of damage to the patches of mangroves and coastal vegetation as well as detailed impacts and risk analysis needs to be undertaken.

4.3. Coral reefs

Somalia has excellent fringing and patches of coral reefs along the Gulf of Aden coastline and southern Somalia near the Kenyan border which are highly bio-diverse. The rock-like structures of coral reefs serve as a natural water break; a physical barrier near the ocean's surface that breaks waves offshore and dissipates most of their force before they reach the land. Therefore, they have the capacity to create rigid, wave-resisting structures that modify their physical environment, thus creating a wide variety of associated depositional movements.

There may be significant damage to the coral reefs as a result of land runoff of wastes and pollutants, debris, soil and organic matter, particularly, those near the coastal towns of

Kismaayo and Mogadishu. Due to the absence of appropriate national institutions there are no mechanisms to assess the damage to coral reefs by natural hydrological related disasters and human activity and nor are there plans for their protection. An assessment of the coral reefs is therefore needed to determine the extent of damage caused by natural disasters such as El Niño as well as general degradation arising from long years of pressure from human activities and management neglect.

IUCN is working with local authorities and NGOs to monitor fisheries and establish a protected area in the Saad ed Din Islands.

4.4. Somalia's soils

It is estimated that from 46 to 56% of Somalia's land area can be considered permanent pasture. About 14% is classified as forest and approximately 13% is suitable for cultivation, but most of that area would require additional investments in wells and roads for it to be usable. The remaining land is not economically exploitable. In the highlands around Hargeysa, relatively high rainfall has raised the organic content of the sandy calcareous soils characteristic of the northern plains, and these soils have supported some dry farming. The area between the Jubba and Shabeelle rivers has soils varying from reddish to dark clays, with some alluvial deposits and fine black soil. This is the area of plantation agriculture and subsistence agro-pastoralism. South of Hargeysa begins the Haud, whose red calcareous soils continue into the Ethiopian Ogaden. These soils support vegetation ideal for camel grazing. To the east of the Haud is the Mudug plain, leading to the Indian Ocean coast; this region, too, supports pastoral grazing.

In general there is soil degradation in Somalia due to poor land use. Degradation is mainly caused by natural phenomena for example drought and floods giving rise to soil erosion which in turn is exacerbated by overgrazing, deforestation (uncontrolled firewood and charcoal production for domestic use and exports) and human population pressures (settlements and refugee and IDP camps). Proper land use and good soil management is therefore key to the development of agriculture in Somalia on which the livelihoods of the majority of the population depend. Assessment of land utilization and management and detailed analysis of impacts of disasters and other activities is crucial.⁴⁰

4.5. Marine and coastal environment

The coastline of Somalia is 3,898 kilometres long and about 55% of its population lives along this coastline. With an area of continental shelf of 40,392 square kilometres and territorial sea of 68,849 square kilometres, it produces about 900 metric tonnes (1997 estimate) of molluscs and crustaceans and 20,000 metric tonnes (2000 estimate) of marine fish. The coastline consists of patches of swamp and related vegetation which includes mangroves

⁴⁰ See also: Vargas, R. R., Omuto, C.T., Alim, M.S., Ismail, A., Njeru, L. 2009: FAO-SWALIM Technical Report L-10. Land degradation assessment and recommendation for a monitoring framework in Somaliland. Nairobi, Kenya. They give a detailed account of the historical context of land degradation in Somaliland, stating that the demarcation of land into agricultural production and pastoral areas allowed soil erosion, nutrient loss and loss of vegetation to take root following the collapse of central government in 1990 and with it the extension services and law and order.

and savannah related vegetation. The coastal and marine environments have been subjected to a variety of pressures including erosion, oil pollution, waste dumps, human settlements and the discharge of municipal waste water due to the lack of proper water and sanitation facilities.

Somali waters have a high potential for fishing. As a result, there is a large number of foreign vessels illegally fishing in Somali waters and serious pollution caused by vessels discharging toxic waste. Heavily armed foreign boats have often tried to exploit the breakdown of law and order in Somalia since the overthrow of President Mohammed Siad Barre in 1991 by fishing in the rich Somali waters, thus depriving coastal communities of resources. However, there has not yet been any fish stock assessment undertaken for the country to enhance better management decisions for the efficient utilization of this resource.

4.6. Solid waste collection and disposal

Prior to the civil war (1991), domestic and commercial solid waste in cities was collected and transported for disposal. However, the system of waste collection and disposal eventually collapsed due to lawlessness and lack of proper central government to efficiently manage the system. During the civil war, waste collection services ceased to function and the collection vehicles and equipment were either looted or destroyed. The garbage transfer stations and depots were also damaged. As a result, mountains of waste accumulated, which continue to pose serious human health risks and environmental hazards.

Further, Somalia is one of the many countries that reportedly received countless shipments of illegal nuclear and toxic waste dumped along the coastline. Starting from the early 1980s and continuing into the civil war, the hazardous waste dumped along Somalia's coast comprised radioactive uranium waste, lead, cadmium, mercury, industrial, hospital, chemical, leather treatment and other toxic waste. Most of the waste was simply dumped on the beaches in containers and disposable leaking barrels which ranged from small to big tanks without regard to the health of the local population and any environmentally devastating impacts.

The issue of dumping in Somalia is contentious as it raises both legal and moral questions. First, there is a violation of international treaties in the export of hazardous waste to Somalia. Second, it is ethically questionable to negotiate a hazardous waste disposal contract with a country in the midst of a protracted civil war and with a factionalized government that could not sustain a functional legal and proper waste management system.

Contamination from the waste deposits has caused health and environmental problems to the surrounding local fishing communities including contamination of groundwater. Many people in these towns have complained of unusual health problems as a result of the contamination. The health problems include acute respiratory infections, dry heavy coughing and mouth bleeding, abdominal haemorrhages, unusual skin chemical reactions, and sudden death after inhaling toxic materials.

It is important to underscore that since 1998, the Indian Ocean has experienced frequent cyclones and heavy tidal waves in the coastal regions of Somalia. Natural disasters are short-

term catastrophes, but the contamination of the environment by radioactive waste can cause serious long-term effects on human health as well as severe impacts on groundwater, soil, agriculture and fisheries for many years. Therefore, the current situation along the Somali coastline poses a very serious environmental hazard, not only in Somalia but also in the eastern Africa sub-region.

4.7. Water and sanitation

Access to safe water is a significant problem in Somalia, aggravated by the destruction and looting of water supply installations during the civil war, the continued conflict and the general lack of maintenance. This situation is compounded by erratic rainfall patterns that exacerbate both drought and sporadic flooding. It is estimated that 65% of the population does not have reliable access to safe water throughout the year. Less than 50% of Somalis live in households with sanitary means of disposing excreta.

The poor water supply has resulted in communities and families digging independent uncontrolled wells. This has led to the heavy reliance on ground water and risks to human health, resulting from poor sanitation and the total breakdown in solid waste management.

The impact of poor environmental sanitation is particularly felt in the cities, towns and large villages or other places where people live in close proximity to each other. Human and household waste disposal sites are generally close to dwellings and water sources. Lack of garbage collection and proliferation of plastic bags has considerably affected the urban environment and water sources. Seepage from the garbage continues to contaminate ground and surface water thereby posing risks to human health and the environment.

5. ENVIRONMENTAL CHALLENGES IN SOMALIA⁴¹

5.1. Challenges

With respect to sustainability of the environment, there are a number of challenges that the sector is facing some of which include:

- Increased deforestation due to increased demand for arable land and failure to enforce measures to curb problems of deforestation;
- Lack of community participation in environment and natural resources management;
- Lack of borehole maintenance and environmental degradation which in turn results in low water table.
- Poor quality of surface and ground water; and
- Inequitable promotion of improved sanitation facilities.

⁴¹ TFG Somalia, 2010: Somalia MDG Progress Report.

5.2. Recommendations for addressing the challenges

- Promotion of community participation in environmental and natural resources management;
- Implementation of a tree planting season to address deforestation;
- Improvement of access to safe water and sanitation by strengthening and building capacity for common water resources management, monitoring systems, rehabilitation and construction of small community earth dams;
- Prioritization of climate change, natural resources and environmental management as one of the nine key priority areas in the MDGs.

6. FLOOD IMPACTS IN SOMALIA

Floods are the most prevalent form of natural disasters along the Juba and Shabelle Rivers in Southern Somalia, whereas flash floods are common occurrences along the intermittent streams in the northern part of the country. Both riverine and flash floods cause high numbers of casualties and economic impacts. As the population grows and urban development encroaches into traditional floodplain areas, in the riverine areas, and in the towns of Garowe and Hargeysa, the potential for loss of life and property will rise in the coming years. For example Hargeysa and Garowe cities in northern Somalia have grown rapidly due to high influx of immigrants resulting from the long civil war. Due to lack of legislations, many people have settled in floodplains risking their lives and introducing high vulnerability. Early warning and alert systems are not in place and if they existed, are rudimentary. Establishing flood early warning systems for the areas at risk of flooding is the most effective means to reduce the death toll caused by these floods⁴².

The flooding frequencies have increased over the last few decades with great damage to property and human and livestock lives being high. Cases of flooding were experienced in 1961, 1977, 1981, 1997, 2005 and 2006. The last three major flooding events had magnitudes larger than the one associated with the historical 50-year return period flood event.

The increase in both severity and damage (both economic and casualties) caused by floods, apart from the natural increase in frequency and severity, is due to several other human made factors:

1. The encroachment of people upon traditional floodplains, as population increases and pressure on land increases, is leading to enlargement of the number of people dwelling in traditional floodplain areas. Predictably, as more people start living in floodplains, the potential for loss of life and property will rise.
2. The major flood relief channels that were maintained by the Somali government departments before the start of the civil war are in disrepair. Floods that are caused by the poor state of the flood relief canals occur mostly in the Lower and Middle Shabelle areas.

⁴². Guleid A., Gadain H.M., Muthusi F.M. and Muchiri P.W. (2007), Improving Flood Forecasting and Early Warning in Somalia, Feasibility Study; Technical Report No W-10, FAO-SWALIM, Nairobi, Kenya.

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3. The deterioration of the river embankments and the unrestricted breaking of river embankments for irrigation purposes often lead to flooding during periods when the river levels are still below historical bank full stage.

Flood control measures are normally should be implemented, both structural and non-structural. Some of the structural measures that are needed immediately in Somalia for areas along the Juba and Shabelle Rivers are (a) the repair and rehabilitation of the major flood relief and irrigation canals (some irrigation canals had a dual purpose of flood relief), and (b) the repair of the numerous breakages in the river embankment.

The non-structural flood control measures needed are (a) the establishment at the national level of a Flood Forecasting Centre for the riverine areas and formation of community-based Flash Alert Centres and needed resources for the dry seasonal streams of the Northern regional states, and (b) the implementation of legislations and policies on land use that should restrict permissible economic activities in the floodplains.

During the floods of 1997/1998, exceptional rain amounts were received throughout the two basins. All the settlements along the Juba River in Somalia were flooded, with some villages cut off completely by the water for extended periods of time. For the Shabelle, many villages along the river were under water for a prolonged period. Hundreds of thousands of people were left homeless with the floods affecting negatively the lives of up to 1 million people. The 1997/1998 floods were estimated to have caused about 2,000 deaths and displacement of about one million persons. These floods led to the collapse of virtually all the large irrigation schemes and damaged all major flood relief channels, roads and other major infrastructures.

During the minor wet season (Deyr) of 2006 (October-December), torrential rains that fell in Ethiopia, Kenya, and Somalia led to large scale flooding in many locations along the Juba and Shabelle Rivers in Somalia. In some areas of the two basins, recorded rainfall during the Deyr season of 2006 was estimated to have been more than 200 to 300 percent above the normal rainfall of the area. It was reported in early November of 2006 that the stage of the Shabelle River at Belet Weyne surpassed the mark of the flood stage associated with river flows of the 50-year return period. The river submerged the main bridge of the town, and most of Belet Weyne was under water for several days. For the Juba River, it was estimated that the stage at Luuq reached the 20-year return period flood stage. In early November 2006, it was estimated that 350,000 people living along the rivers were displaced, inundated, or otherwise seriously affected by the floods with the possibility of up to 90,000 people being displaced before the end of the minor wet season⁴³.

7. FLOOD WARNING SYSTEMS

7.1. Swalim system of flood warning

SWALIM operates a flood warning system in the areas of the Juba and Shabelle rivers. SWALIM combines the observed river water levels, at the previously its hydrometric

⁴³ Guleid A., et al, *ibid*.

stations, with the NOAA satellite rainfall estimates product and GFS rainfall forecasts that are provided by USGS in a weekly Flood Bulletin that is produced during the Gu (major wet) and Deyr (minor wet) seasons. The bulletin is produced jointly with USGS/FEWSNET. The bulletin is disseminated via e-mail distribution list to various actors in Somalia and Nairobi active in flood relief work, and the bulletin is made available via a Web portal hosted by SWALIM. The e-mail distribution list is continually updated.

7.2. Traditional methods of flood warning

In some of the riverine areas, people use numerous river level marks to monitor the onset of floods. People also use the color of the river water as an indicator of the onset of large-scale surface runoff generation. When the water level in a river approaches warning levels, the news is disseminated by word of mouth and runners. For example, at Jowhar, when the Shabelle staff stage gauge reaches 5.25 m, the Middle Shabelle Authorities send messengers to the villages to warn the communities about the potential for floods. At Jowhar they also make contacts with authorities at Belet Weyne and Bulo Burti for river levels information at those locations. Any flood forecast system that is put into place in the future should be tied to marks left by the major flood events, marks that are easily understood by large sections of the riverine populace.

7.3. Flash floods

A flash flood is a flood that rises and falls quite rapidly with little or no advance warning, usually as a result of intense rainfall over a relatively small area. Flash floods may occur suddenly and be accompanied by other hazards such as landslides, mud flows, damage to infrastructure, and even death. During the last two decades, northern Somalia has experienced several serious flash flood disasters in different parts of the region that have resulted in damage to property and loss of lives. The region has a hot and arid climate and a short rainy season with occurrences of intense rainfall events that can result in flash floods. Flash flood events frequently trigger disasters in the area because of the lack of warning and prevention measures in place.

A flash flood event that occurred in May 2005 destroyed a large section of the Garowe-Bosaso road. The road was reported to have remained impassable for several days. In Somaliland, specifically in Hargeysa city, one of the two main bridges was washed away in April 2005, leaving many parts of the city inaccessible. A major bridge on the Madoori Jeex Wadi in Hargeysa was washed away during the flash flood of May 2005. An interagency assessment estimated that these floods affected slightly over 1,000 families.

A recent flash flood event in Somaliland took place on April 14, 2007, in Allaybaday, where 87 earth dams out of the 105 dams that are used for supplemental irrigation were destroyed and washed away, with farm fields being inundated and irrigation infrastructure destroyed. No human casualties were reported, only livestock deaths. The destroyed dams supported the livelihoods of about 10,000 people.

Garowe Town, the capital of Nugal Region and Puntland State of Somalia is another

vulnerable town to the ravages of flash floods. The main stream (togga) draining into the city is one of the tributaries of the Nugal Tog and it originates from the southern part of the region. The area of the basin is estimated at less than 600 km² with little information available to define its relevant characteristics compared to the Hargeysa River.

Even though Garowe City and the surrounding areas are hot and dry, the city has experienced several destructive floods during the past few years (e.g., 2004 and 2005). The city extends along and borders the main stream. Despite the fact that rainfall in the areas is usually low, with annual rainfall averaging only around 130 mm, there is the possibility of an amount equivalent to the total annual rainfall falling in few days or even in a single day. Due to the basin's vegetation and soils inability to store water and their low infiltration capacity, more of the rainfall becomes runoff than in other basins of comparable size. Although runoff is high, a great portion of it evaporates in the flat lands.

Vulnerability to floods is defined as the degree of loss to a given community resulting from the occurrence of a flood disaster. Some of the communities closest to the toga are the poorest neighborhoods of the city and accordingly the least prepared and the most vulnerable to the effects of floods. Many IDPs and informal settlements along the toga pass beside the city.

Hargeysa City is the major capital of the Somaliland and Wagooyi Galbeed region with a population of 500,000 to 700,000 people. The city has grown in the past 10 years mainly because many people from the south and east of the country have migrated to the city due to the political stability in the region. The main stream draining the city is Toga Maroodi Jeex, which divides the city into two major localities. High numbers of people live around the floodplain, increasing the vulnerability to flooding especially among the poor and the IDPs. The city lacks planning and land use legislation. With the result that many people have built in the floodplains of the Toga Maroodi Jeex, increasing the vulnerability of lives and assets to flooding.

7.4. Flooding and land degradation

Besides the spatial and temporal variability of rainfall, the following reasons are considered the main factors behind many of the flash flood problems in the region:

- a)** absence and lack of efforts to regulate and manage seasonal river flows;
- b)** land degradation and soil erosion caused by felling trees from river banks, thereby weakening the river banks;
- c)** Improper practices of rain water collection;
- d)** absence of urban land use planning, management, and legislation with the results that homesteads and businesses have been sprouting along the river banks;
- e)** lack of proper drainage systems in urban centres;
- f)** lack of maintenance of the flood protection dikes and
- g)** absence of community awareness.

8. SHARING OF REAL TIME TRANSBOUNDARY INFORMATION FOR FLOOD CONTROL

Although 90% of the water of the Juba and Shabelle Rivers originate from Ethiopia, there is presently no transboundary hydro-meteorological data sharing between the two countries. The stream flow data from a real-time observing system on the Juba and Shabelle Rivers and tributaries in Ethiopia will be extremely beneficial to flood forecasting activity for the areas along the Juba and Shebelle Rivers in Somalia. For example, an automated stream gauge station on the Shabelle at Godey will increase flood-warning lead-time by about two or three days for all the forecast locations on the Shabelle Rivers that are located in Somalia⁴⁴.

Ethiopia operates a network of stream gauges along the Shabelle River and on tributaries of the Juba on the Ethiopian side of the two rivers. An effort should be made to establish cooperation with Ethiopia on stream flow data sharing. Helping Ethiopia to establish real-time telemetric stream gauge stations could be the way to foster such cooperation. Another point of cooperation will be sharing information on the timing of water releases for dams upstream on the two rivers where such dams exist.

One avenue for information and data exchange would therefore be the IGAD framework – it is hoped that the situation between the two countries can normalise sufficiently to allow for this information and data exchange to happen within the IGAD framework.

⁴⁴. Guleid A., et al, *ibid*.

ASSESSMENT OF FLOODING AND EROSION RISK ON DJIBOUTI

1. INTRODUCTION

Djibouti is reported to have very variable weather patterns and low rainfall but even small rainfall of 10 mm can lead to devastating flash floods on the otherwise dry river beds.

Most gardens are grown along the banks of wadis and alluvial terraces and because these areas contain good soil (loam lately) and provides access to higher quality aquifers. The plots installed on these terraces are therefore subject (i) to erosion by undercutting of banks, (ii) flooding during heavy floods, and (iii) the gully by runoff.

While overall, all the plots irrigated plain Gobaad suffer the vagaries of the Oued, the geographical location and geo-morphological features of the area mean that the risks are not the same everywhere. Some parcels of arable land in the flood plains of the Oued risk of flooding nearly every year resulting in loss of land and sometimes harvest.

Runoff along rivers occurs in the absence of dissipation of energy. The result is the undermining of the banks and erosion of the river beds. This erosion causes great damage to access routes and requiring the perpetual and expensive care as was the case in the region where Tadjourah often feel the impact of traffic disruption on the rural supply route.

In areas of Dikhil and Ali Sabieh, this erosion is causing the destruction of gardens and the destabilization of the operation of the irrigation system of alluvial terraces.

Wind erosion is most active against the inland plains (Hanleh, Grand Bara, Gobaad, etc.) and in the coastal area of Obock, but this has not been assessed and no information on risk of erosion is available⁴⁵.

The main attempt to reduce erosion is by construction of earth dams to reduce the speed of the water.

The government set up an emergency response unit to manage the crises of flooding such as that of 1994 where loss of lives and livestock was witnessed. This unit coordinates the relief efforts. The government also rehabilitated the Ambouli Dike which collapsed catastrophically in 1994; in November 1994, rainfall exceeded 360 mm in Djibouti in the space of two days.

The maximum annual monthly precipitation is observed in the mountains west of Tadjourah

⁴⁵. Republic of Djibouti: Final Environment Report prepared for the OSS Project.

(Goda massif). Rainfall decreases sharply towards the north-east towards the coast at Obock-Khor Angar-Doumeira with 50 to 100 mm per year. In the northern parts of the country, the average rainfall varies between 100 and 150 mm (Dorra-Balho), whereas in the western regions (plains Hanlé and Gobaad) rainfall exceeds 150 mm. On the coastal plain south of the country, the annual precipitation is between 130 and 200 mm, and decreases towards Dikhil. The mountainous regions north of the Gulf of Tadjoura (1 382 to 1 783 m) enjoying a mild climate and more abundant precipitation, biodiversity is largely concentrated in this part of the territory with the two great forests of the country (Forest Day and Mabla)⁴⁶.

The annual average temperatures have risen continuously for several decades in the Republic of Djibouti. The rise of the temperature levels coupled with high population growth and rural exodus has resulted in increasing drinking water needs of the population whereas there is scarcity of supply.

Rising sea levels between 0.08 m and 0.39 m and increased rainfall in Djibouti City of 17.1% represents the main consequences of climate change. Flood stage of 1.88 m was related to the contour of 2 m and 2.78 m to that of the contour of 3 m. These flood levels will affect the minimum and maximum respectively 1440 ha or 25% of the total area of the city and 1880 ha or 35% of the area of the city. The areas include residential areas, areas of economic and administrative activities, public facilities, military zones and natural areas and expansion. With these scenarios, these are essentially areas of economic and administrative activities on the one hand, and a very large proportion of residential housing and other natural areas that are severely affected by rising sea level⁴⁷.

Some key dates regarding flooding in Djibouti⁴⁸:

- April 1989: catastrophic flooding resulting from rainfall that occurred over two days across the country and particularly in the capital caused human and material damage in the whole country and particularly in the capital;
- November 1994: the floods killed nearly 105 people and caused the destruction of infrastructure (roads, houses), livestock, crops and farms estimated at 39 billion Djibouti Francs (exceeds the annual state budget; source: National Committee for Disaster Management);
- In 1997, floods (whose magnitude was less than in 1994) also caused massive damage especially in rural areas on farms and livestock;
- In August / September 2003, wadi overflows caused the destruction of water infrastructure (wells, ponds, cultures) on farms, especially in the agricultural districts of Assamo, Atar / Damerjog, As-Eyla and Hanle.
- In April 2004 (the night of 12 to 13), exceptional rainstorms occurred throughout the country and with greater intensity in the catchment area of Wadi Ambouli (which takes its source in the Plain Petit Barra, travelling more than 60 km to its outlet) caused flooding of greater magnitude than all other floods (the last flood similar to this took place in 1927)

⁴⁶ Government of the Republic of Djibouti, Socioeconomic Report, prepared for the OSS Project.

⁴⁷ Government of the Republic of Djibouti, Initial Communication to the UNFCCC, Dec. 2001.

⁴⁸ Republic of Djibouti, National Adaptation Plan of Action (NAPA), 2006.

particularly in the area the capital. In other districts, the flood magnitude was smaller; however, livestock losses, destruction of infrastructure (roads, silting of wells) and cultural sites, fences, etc... Losses caused by this flood on the agricultural terraces of the wadi Ambouli include: 655 head of cattle dead or missing, 2,064 heads of small ruminants dead and nearly 30 tons of animal feed lost. The floods caused huge human and material damage, including total loss of about two hundred lives and extensive damage reported in the infrastructure (i.e. roads, water supply, electricity, houses...). The damage was estimated at several tens of billions of Djibouti Francs.

The flood prone areas in the City of Djibouti, which has 65% of the population, is given in the figure below.

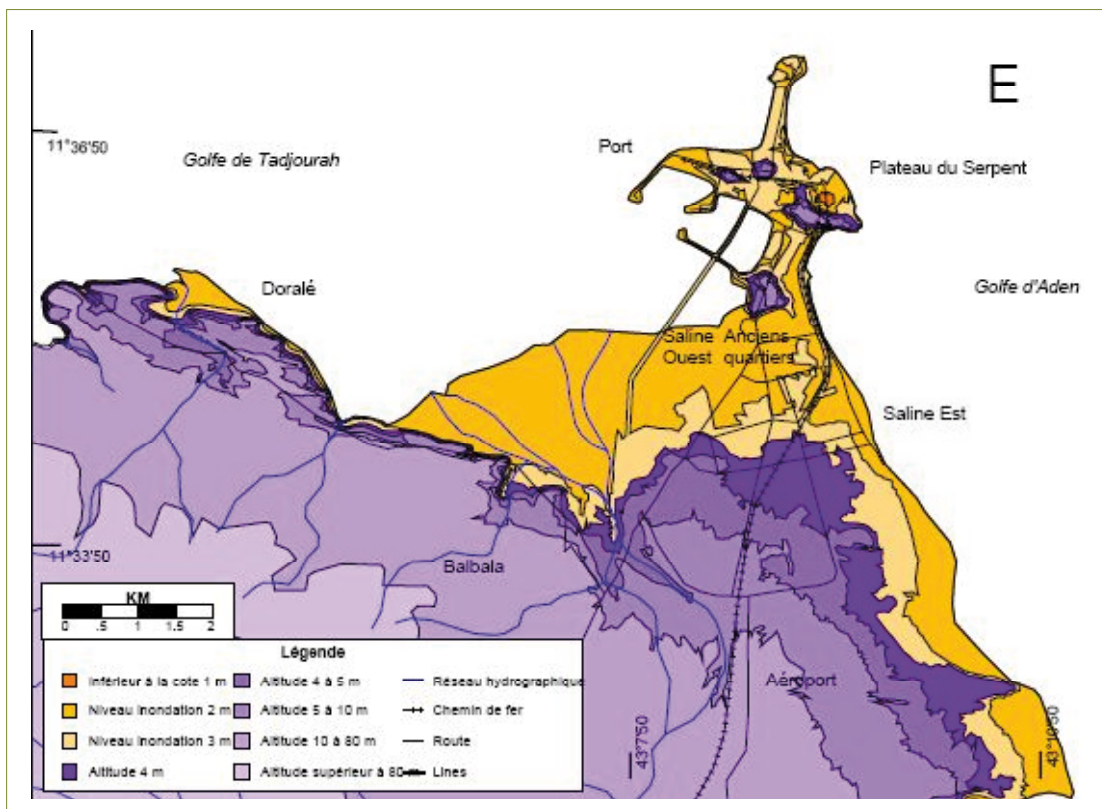


FIGURE 14: The levels of flooding in the area of the city of Djibouti.

Government of the Republic of Djibouti, Initial Communication to the UNFCCC, 2001.

2. COPING STRATEGIES

The effects of flooding in Djibouti have been felt as recently as 1994 and again in 2004 when over 50 people died in their sleep from the flooding of wadi Ambouli.

The National Adaptation Program of Action (NAPA) gives a comprehensive assessment of the problem and also the financial outlays required for mitigation of the problem⁴⁹. However, little is said about the actual projects that would be financed within the NAPA, except to state the amounts required.

⁴⁹. Government of the Republic of Djibouti, Final Environment Report prepared for the OSS Project.

Adaptation options articulated in the NAPA aim both to alleviate the impacts of climate change by enhancing adaptive capacity of vulnerable populations but also to contribute directly to the implementation of the Poverty Reduction Strategy Paper (PRSP).

NAPA supports the development of synergies with on-going initiatives in the Republic of Djibouti in environmental in particular and in all activities under the NEPAD, but also those supported by the Global Environment Fund or United Nations Conventions on environment.

NAPA also establishes links with projects which focus on national development priorities at the same time as it promotes dialogue, exchange of information and cooperation between different stakeholders, governmental and non-academic sectors and private sectors. By working together, climate change will have more chance to appear on the agendas of each other and therefore be incorporated into planning systems and processes for formulating development strategies.

The findings of the vulnerability studies converge in effect on the critical vulnerability of vital sectors of national economy while laying the roadmap so that the NAPA objectives are integrated into all planning systems and sector strategies. It is this aspect of complementarities of NAPA that has been preserved to the phenomena of variability and climate change issues in all sectors. Their socio-economic situation is a national concern because calamities are disastrous to all and response capabilities to adapt very limited.

Therefore, to ensure a better quality of life for Djiboutian people, it was very important for stakeholders to delineate the process of NAPA in an original frame with a prospective long-term vision, with a mission defined in the specific objectives of the NAPA.

High tide prevents natural drainage of rainwater and the wastewater drainage system because of the topography whose slopes severely limit the flow. The flooding of the city is the main consequence of inadequate drainage of storm water especially since some older neighbourhoods are below the level of high tide. Major work on filling, enhancement of the plots, storm water drainage and sanitation can improve the drainage, but not a permanent solution to flooding problems in the city and sanitation⁵⁰.

The small catchments in Djibouti make an early warning and forecasting/disaster preparedness strategy essential to avoid the kind of catastrophic flash floods already discussed. It is therefore essential that these early warning and forecasting equipment, personnel and food and aid reserves are put in place so that they are readily deployed when required.

⁵⁰ Government of Djibouti: Initial Communication to the UNFCCC, Dec. 2001.

ASSESSMENT OF FLOODING AND EROSION RISK ON ETHIOPIA

1. INTRODUCTION

Ethiopia relief is categorised into highland, moist and dry lowlands. The highlands receive higher rainfall and are the source for the various rivers flooding downstream. The highland terrain plays an important role in soil loss and majority of the soil loss in the country is exhibited in these cultivated highland areas. On the other hand the terrain along many of the rivers provided the country ample opportunity for construction of cost effective dam and reservoirs.

In the lowlands, malaria and various water related diseases are common. Compared to the highland, the people and the livestock density in the lowland area are very low due to the harsh environment and epidemic of various human and livestock diseases. The lowland extends from the central highland towards the border of the country in all directions.

Some of the highlands are already heavily eroded and coupled with high population in the zone (70% of the population lives in the highlands), may not tolerate erosion anymore. Hence, irrigation and other development in the lowland area will contribute in reducing the present high population in the highlands⁵¹.

Soil loss rate (Figure 15) is at higher level in the Ethiopian highland areas (> 1500 m.a.s.l) and in the surrounding lowland soil loss rate is slight to none. This lowland spreading all over the country surrounding area covers about 70% of the total country cover. Majority of this lowland area is covered with shrub and shrub grassland and has low population density. Apart from topographic features, the land use and land cover (Figures 16 & 17) condition contributes minimal to nil soil loss rate. Almost all of the very high and high erosion rates and majority of the moderate erosion rates are found in the highland area of the country. The rate of soil erosion in this highland area includes about 12% moderate, 9% high and 3% very high. The total annual soil loss from these areas for the country was estimated to be about 3.9 billion tons/year. In terms of area cover, the high and very high erosion area is very small yet resulted in about 3 billion tons/year which is about 75% of the total soil loss of the country.

The two major river basins dominated very high soil erosion rate are the Tekeze and Abay river basins. Majority of the area of the basins is dominated with steep slopes and was

⁵¹. Government of the Republic of Ethiopia, Environment Assessment Report, prepared for the SSO Project, 2009.

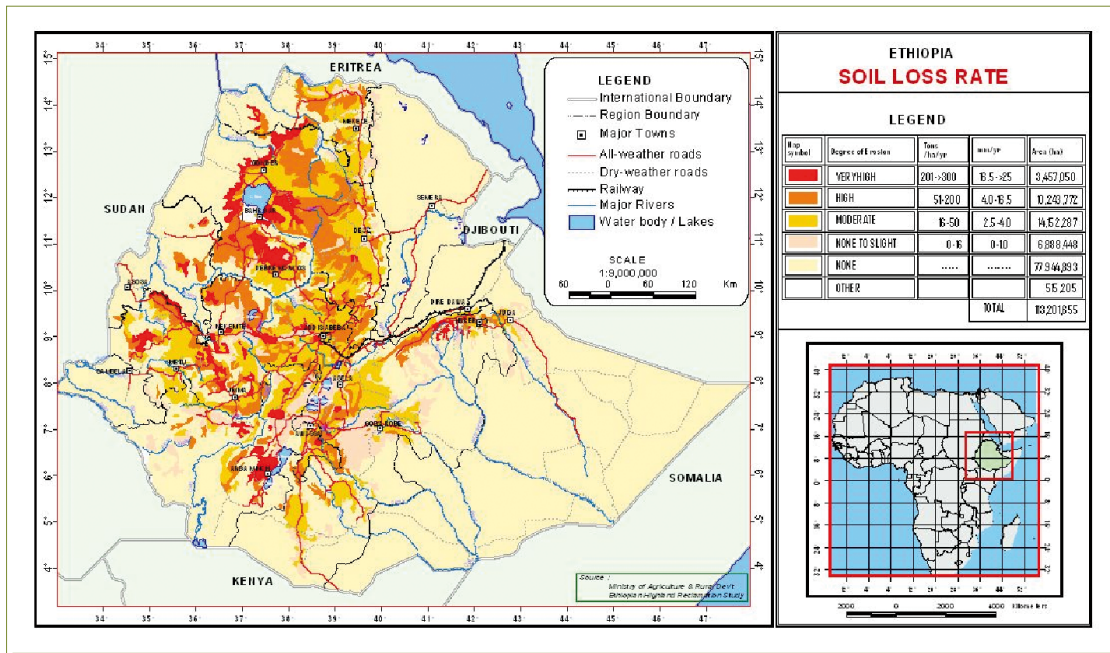


FIGURE 15: Soil loss rate categories in Ethiopia

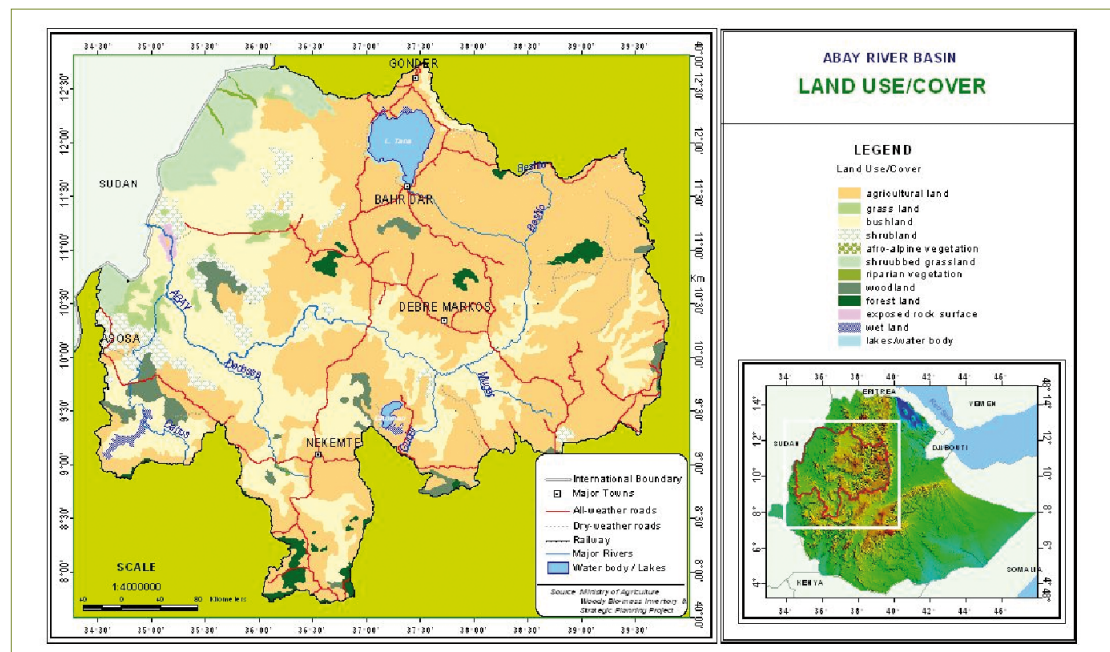
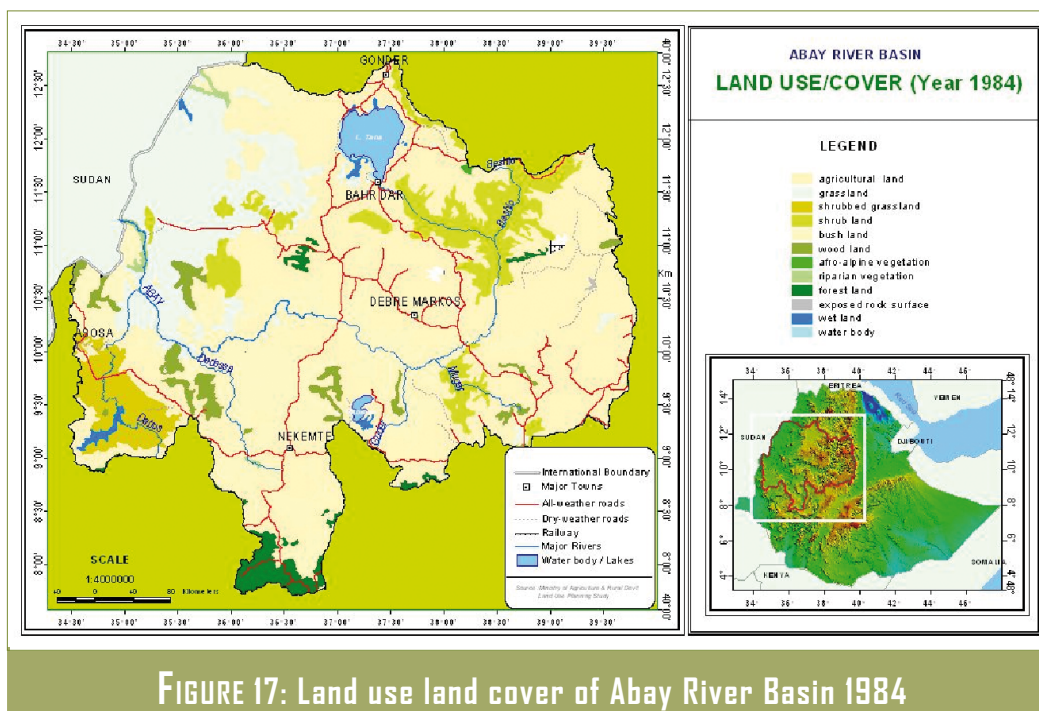


FIGURE 16: Land use/cover in the Abay river basin 2000

cultivated for centuries without the necessary soil erosion and land management measures. Other typical areas with severe erosion rate include the Sodo highland that drains in to Lake Arbaminch in the RVLB, the steep slopes and gorges between Harar and Dire Dawa in Awash River Basin. Apart from contributing to land degradation, soil erosion will be a critical challenge of dam construction due increased sediment risk of reservoirs.



2. EROSION HAZARD IN ETHIOPIA

Factors that are considered in potential erosion hazard assessment include rainfall erosivity, topography, soil characteristics, land use / land cover and land management practice. The main forms of soil erosion are rill, sheet and gully erosion. The presence, distribution and causes of this soil erosion should be established based on evidence and better scale.

In the lowland area which covers majority of the country area, rainfall is minimal, population is sparse and crop cultivation is very much limited, the vegetation cover is more of shrub and shrub grassland which does not allow or facilitate erosion. The factors together or alone play a positive role in maintaining the soil condition hence erosion hazard in the lowland area is low to none.

The risk of erosion hazard (Figure 18) in the highlands of Ethiopia could be seen from various factors that play unilateral and cumulative role through time. High population density registered in the highland area coupled with the major means of livelihood, agriculture (crop production or more livestock overgrazing the steep part) then the soil erosion hazard would be extremely high. The rainfall and slope factors in this area cannot be changed; however a lot can be done to minimize the erosion hazard through playing on establish better vegetation cover, reduce population growth and effectively reduce pressure on land through creating non-farm income generating activities and conduct other better land management practices.

3. FLOOD SITUATION IN ETHIOPIA

The Ethiopian Highlands are the source of water that dissipates into the lowlands where

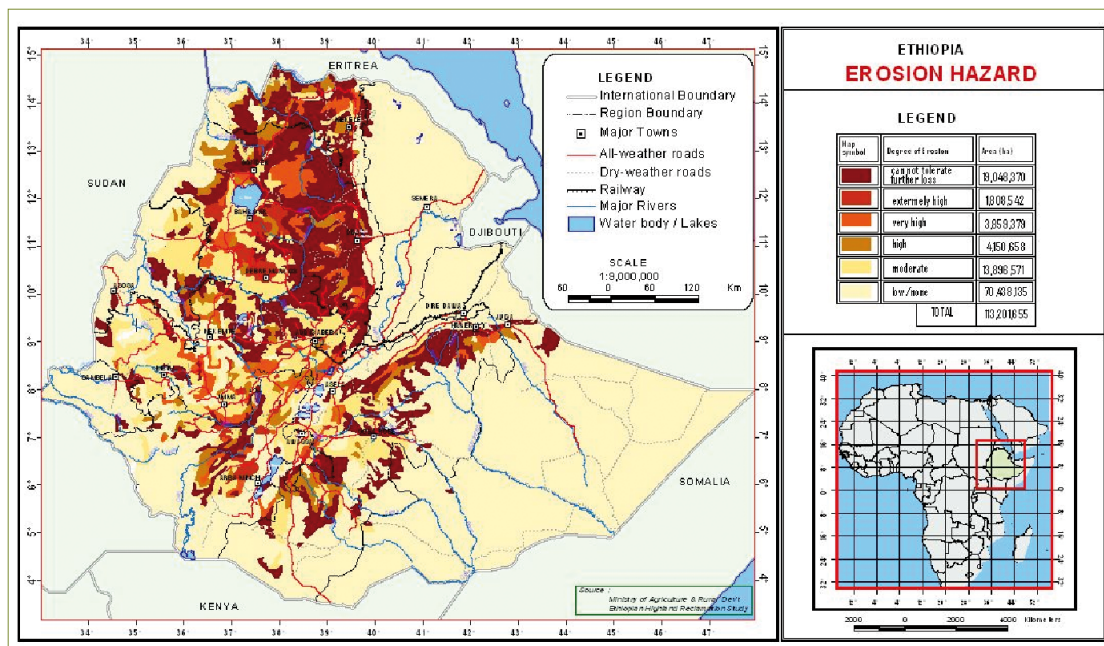


FIGURE 18: Soil Erosion hazard in Ethiopia

flooding often occurs. Flood and drought (Figures 19 & 20) phenomena are strongly interrelated in Ethiopia and the extent of people affected by flood stands next to the drought, although flooding is a more recent phenomenon. Some of the main critical environmental settings that are related with flooding includes climatic condition (occurrence of intensive rainfall in limited period); flat & plain topographic feature in the lowland & steep sloped catchments with poor vegetation cover. Flash flood and river floods are the most common and recurrent flood types in the country.

Flooding around Lake Tana is reported due to rise in the lake level but the magnitude and frequency of lake level rise that could led to flooding is rare and the damage could be considered insignificant. Moreover, various water resource development projects that are implemented recently in lakes surrounding area could regulate the amount of water in the lakes there by reducing flood risk in the fogera plain land.

Flash floods are formed when excess rainfall falls in drainage basin and with topographic feature that facilitates fast run off. The magnitude and impact of the flood depends on the intensity area cover and length of the rainfall. Generally, these floods are distributed and recurrently occur in the country & it would be difficult to design warning systems and protection for such floods yet the cumulative damage on crop and property and the implication to the overall country economy remains high. The 2006 flood that hit Dire Dawa town could be taken as an example of flash flood. The flood during this period affected a total of 700,000 people of which 200,000 are displaced and 600 casualties on people. Various crops grown on about 60,000 ha were damaged.

4. COPING STRATEGIES

Ethiopia is preparing flood forecast and early warning and preparedness

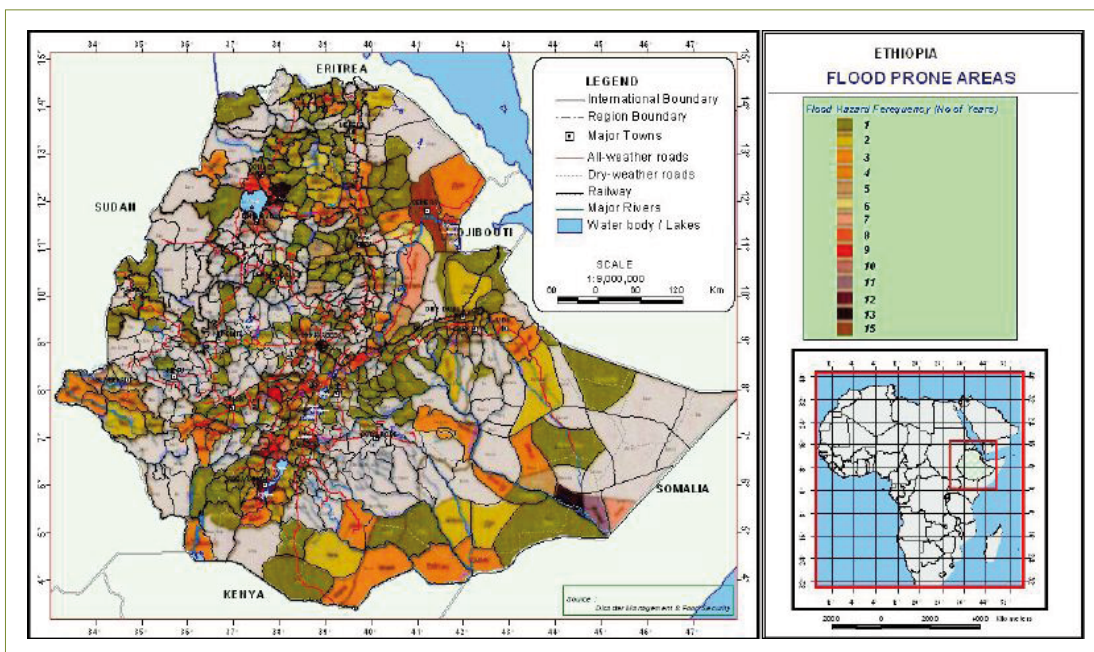


FIGURE 19: Flood hazard map of Ethiopia

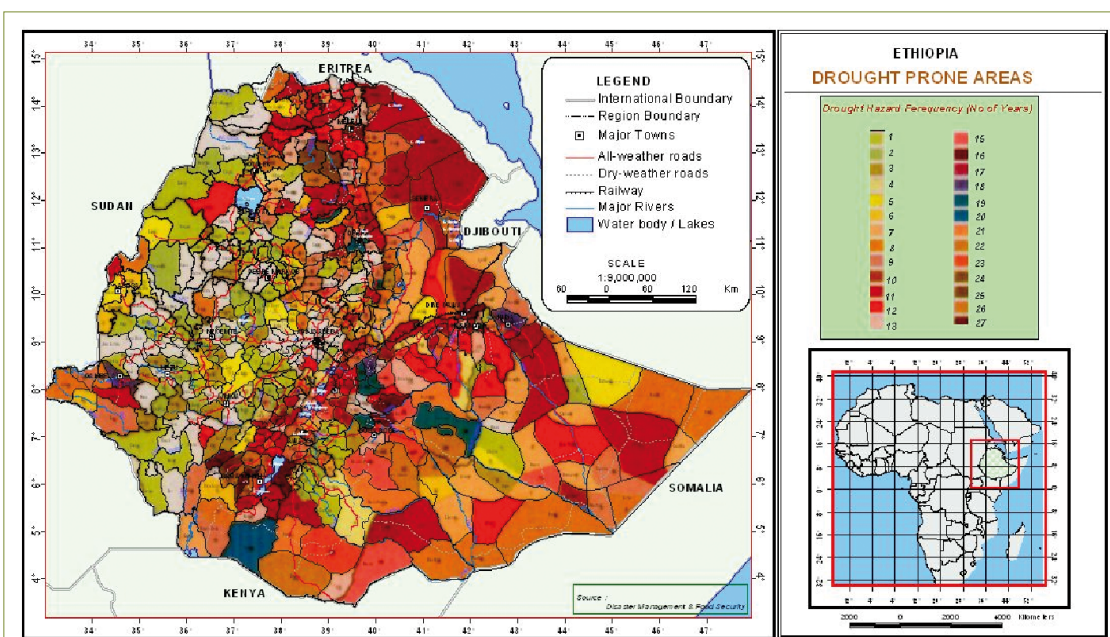


FIGURE 20: Drought Hazard Frequency in Ethiopia

mechanisms to cope with the large floods. Stakeholder institutions that could play key role in the prevention and early warning are the Ministry of Water Resource Hydrology Department & the National Meteorological Agency (NMA), Disaster Management and Food Security division of the MoARD and various international humanitarian and relief organizations. Flood forecast depends on the network of installed meteorological stations and other data required for determining the flood condition. Information about the

early warning depends on the quality and scale of data generated by NMA & hydrology department of the MoWR.

It includes arrangement for evacuation, shelter places, securing required food and medicine, handling of post flood impacts, development models etc. ENTRO with this respect is conducting various software measures on selected flood prone areas.

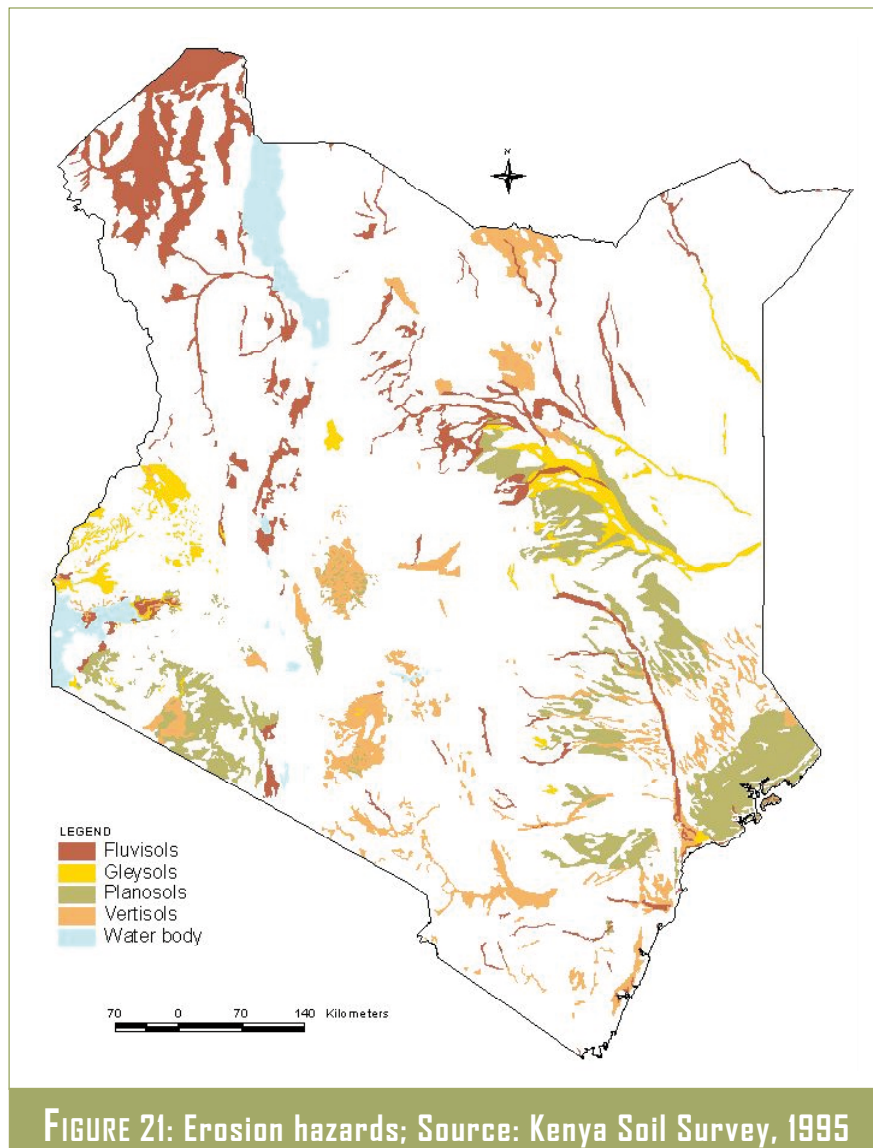
The most effective measure to prevent the impact of flood in the country is construction of high dams that can absorb flood and release regulated flow based on requirements for the downstream area. These dams could be multipurpose which play other roles such as supplementary irrigation and hydropower. The River Basin Integrated Development Master Plan Projects documents prepared for the various river basin indicated various medium and large scale dam projects.

Other sustainable measure to prevent occurrence of flood may include: study & implementation of watershed management projects; Construction of dykes in potential flood areas and avoid establishment of settlement centres and other facilities in flood prone areas.

ASSESSMENT OF FLOODING AND EROSION RISK IN KENYA

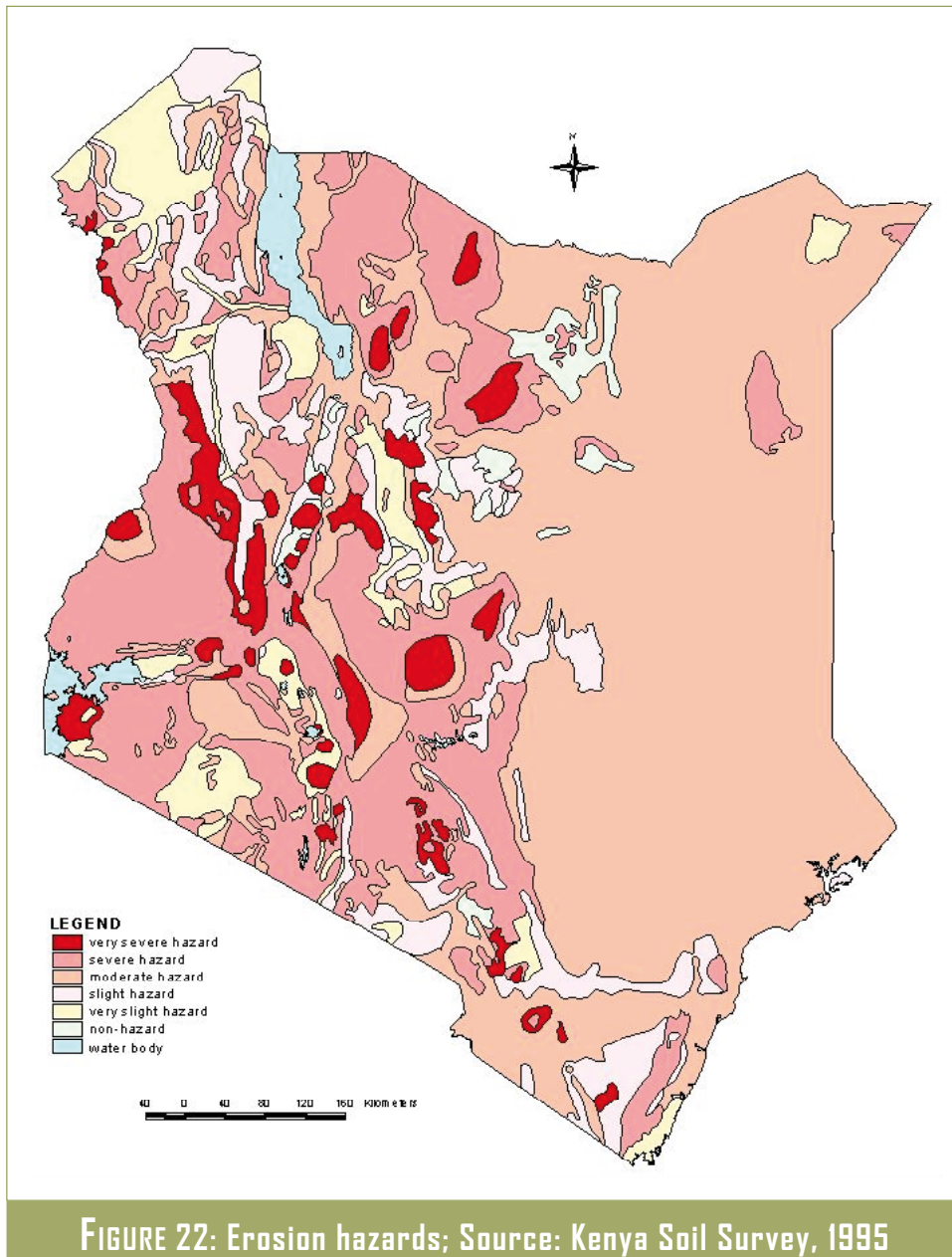
1. INTRODUCTION

The frequency of floods (Figure 21) and droughts in Kenya is noted as a serious problem. Flooding, which is a manifestation of climate change, is frequent in the country. According to the World Food Programme (WFP) estimate in 2006, about 700,000 people were affected



by flooding across the country as a result of unexpected and prolonged rains in some areas namely, North-eastern, Western, Nyanza and Coast provinces.

Farming activities destroy surface cover resulting in reduced recharge of ground water, increased surface run-off, soil erosion (Figure 22) and eventually desertification. The eroded soils are carried by surface flow and deposited in rivers, dams and pans resulting in reduced storage capacity and quality of water. The increased surface run-off causes increased potential flooding and its associated consequences. For example, the destruction of the Mau forest is endangering many of the rivers that flow from it, such as the Mara River.



Deforestation and poor land management practices contribute to catchment degradation in

Kenya. Encroachment on forest lands resulting from high population growth, forest excision and the legal de-gazettement of forest land to create human settlements has accelerated the processes of catchment degradation. The reduction of natural forest cover has led to reduced surface water flow in the dry seasons and the problem of flash floods due to the inability of most catchments to retain water and instead releasing it as surface run-off. Wetlands and forested areas form potential zones for ground water recharge⁵².

Illegal cultivation within indigenous forests has also reduced the forest cover in the country, as has the popular Non-Residential Cultivation or shamba system. The overall impact of the innovative and pro-poor shamba system has been reduced forest cover. Under this system, farmers are given pieces of clear felled plantation forest areas to cultivate while taking care of planted tree seedlings. The farmers are allowed to occupy the plots until the canopy closes or for a maximum of three years, whichever comes first.

However, the system has been 'commercialized' whereby plots are in most cases sold to prospective cultivators. This has led to the current abuse of the system with forest officers either colluding, or taking advantage of the system or failing to adhere to the set NRC guidelines. Cultivators have also resorted to tampering with the trees in an effort to stay longer in a plot to recover the money given to the sellers. The farmers wilfully destroy tree seedlings to extend tenancy. Farmers are also known to extend their farm land into the forest, some by about 30 metres⁵³.

Climate change is also associated with increased flooding/sedimentation, especially affecting the low lying coastal zone where mangroves occur. A small increase in sea level may leave the mangroves submerged unless they can retreat further inland, which is improbable due to human settlements. Agriculture, infrastructure and both tourist facilities and hotspots will also be affected by sea level rise.

The impact of climate change on the Kenya's marine ecosystems include the likely submergence of approximately 17% of Mombasa or 4,600 ha of land area with a sea level rise of only 0.3 m. Over the next century with the projected sea level rise between 0.17 and 0.59 m, the Kenyan coastal development is exposed to considerable risks. In 1997, 1998 and 2006, massive sedimentation due to erosion of terrigenous sediments following extremely heavy rainfall caused mangrove dieback in many areas along the Kenyan coast. Mwache Creek, a peri-urban mangrove forest in Mombasa was the most affected, losing close to 500 ha of mangrove forest⁵⁴.

Rising sea levels will lead to the inundation and displacement of coastal wetlands, the erosion of shorelines, increased salinity and the intrusion of saline water into coastal aquifers. Saltwater intrusion into groundwater resources and salt wedge estuaries are phenomena that have been observed already in some places such as Lamu. The El Niño weather phenomena are also likely to increase in frequency. The port facilities in Mombasa, which lies just 45 m above mean sea level, could be destroyed by the sea level rise and floods that are now more frequent.

⁵². Government of the Republic of Kenya, Environmental Report prepared for the OSS Project.

⁵³. GoK, *ibid*.

⁵⁴. Government of Kenya, Kenya National Climate Change Response Strategy, 2010.

2. COPING STRATEGIES

Kenya's strategy for the mitigation of flooding and siltation is done in the wider context of climate change and the National Climate Change Strategy addresses the issue under the themes of:

■ **Forestry interventions:** trees and forests help the country in mitigation of climate change effects. The plan is to grow 7.6 billion trees on 4.1 million ha during the next 20 years with community participation (35,000 schools, 4,300 women groups, 16,350 youth groups and six Regional Development Authorities. Each school is to be supplied with a 10,000 litre water tank to support water harvesting for the establishment and management of both tree nurseries and plantations. Also large-scale landowners with at least 50 acres of land will be encouraged to construct dams for water harvesting and storage in order to support the establishment of irrigated private forests.

■ **Energy interventions:** these target an energy mix that greatly relies on carbon-neutral energy sources such as geothermal and other renewable sources of power. Rainfall-dependent hydropower electricity generation, which is currently Kenya's main source of electricity, is susceptible to droughts which result from climate change. The strategy therefore envisages the acceleration of development of geothermal resources, which are abundant in Kenya. Approximately 1,000 MW of geothermal electricity can be harnessed at a cost of US\$ 0.06 per kWh in the next three to four years, while still generating substantial revenues for further investment. Geothermal energy resources are immune to extreme weather conditions arising from climate change and escalations in the cost of traditional fossil fuels such as petroleum. Other renewable sources of power include wind, solar and renewable biomass (e.g. ethanol). Improving energy efficiency is also a key target in this regard (mandatory energy audits; review of the tax policies on importation of environmental-friendly and low-fuel consuming motor vehicles such as hybrid designed models, and tax incentives for adoption of fluorescent light bulbs and similar energy saving household gadgets).

■ **Agriculture interventions:** will target the increased use of biotechnology (in accordance with the Kenya National Biotechnology Development Policy, 2006); using waste to produce biogas; improved crop production and agro-forestry practices such as tree inter-cropping and organic farming.

■ **Transport interventions:** In Kenya, the transport sector emissions are growing rapidly due to increases in private car use that is expanding as incomes rise, the middle class expands and the public transport sector continues to erode. The strategy aims to promote low-cost public transport modes such as the bus rapid transit and other means of transport; promote proper urban planning and encouraging modes of transport such as bicycling and walking; phase out inefficient motor vehicles while promoting the use of efficient vehicles. Developing a Light Rail Transit (LRT) in major cities and towns to decongest traffic, and improving the rail network to facilitate low-cost and low-carbon long-distance transportation of cargo and passengers are other measures envisaged.

■ **Carbon market trading:** this targets the Kyoto Protocol's Clean Development Mechanism

(CDM) compliance markets by encouraging individuals and organizations who wish to voluntarily offset their GHG emissions, i.e. under the Voluntary Carbon Markets (VCM).

■ **Communication, Education and Awareness Programs:** these will entail: **communicating** the scientific and technical work of the UNFCCC, the Kyoto Protocol, and the post Kyoto agreement documents in languages that are accessible to many different groups, integrating climate change into **education** systems of all Parties to the Convention, and raising **public** awareness of the importance of climate change and its implications to our lives.

■ **Vulnerability Assessment, Impact Monitoring and Capacity Building:** this targets thorough periodic nationwide assessments of how the climate change impacts affect human population, infrastructure and environment and the economy and society as a whole. Such assessments should lead to the development of essential climate change scenarios and corresponding policy responses. The indicators to be monitored would include changes in the atmosphere, marine and terrestrial biodiversity as well as important ecosystems such as major water towers (the Mau Escarpment, Cherenganyi Hills, Mount Kenya, Mount Elgon and the Arberdare Ranges), major lakes such as Victoria and Turkana, water quantity including river floods and droughts, freshwater quality, agriculture, forestry, and human health, among others.

■ **Research, Technology Development, Absorption and Diffusion:** Research and development is important not only in understanding the causes, manifestations and impacts of climate change, but also in responding to it. The areas of research include agriculture, livestock and food security; energy; forestry; health; water; fisheries and wildlife and rangelands. The aspect also targets technology transfer within the CDM mechanism from developed countries to developing countries. Other technology transfer routes are through UNIDO, North-South technology transfer and South-South technology transfer.

■ **Climate change institutional, policy and legal frameworks:** this targets the formulation of policy that addresses the emerging and present climate change situation in the country since the current policy framework does not adequately address it. A comprehensive policy on climate change should therefore be formulated in line with the UNFCCC's requirement of Parties. An appropriate legal framework is also required to make the policy effective. The legal framework should be based on the Environmental Management and Coordination Act (EMCA, 1999) – which has relevant provisions for mitigation against climate change. Gaps exist in this Act, including the need for development of national inventories of anthropogenic emissions of GHG in Kenya by source and removal of GHG by sinks; national framework for carbon finance; development of national and regional programs to mitigate climate change by addressing anthropogenic emissions by source; promotion of education, training and awareness on climate change; appropriate technology transfer arrangements and their authorization, and access to environmentally-sound technologies.

■ • The existing institutional arrangements are diffuse and confusing, with multiple departments and agencies coordinating components of the climate change activities. The government therefore plans to improve the climate change governance system – guided by appropriate policy and legislation – that will facilitate the implementation of the KNCCRS. A **Climate Change Secretariat** is proposed and a **National Climate Change Steering Committee**

⁵⁵. Government of Kenya, *ibid*.

(NCCSC) be established by MEMR to help it gather and collate input and advice from key climate change stakeholders for its use in the coordination of Kenya's climate change activities⁵⁶.

⁵⁶. Government of Kenya, KNCCRS, 2010.

ASSESSMENT OF FLOODING AND EROSION RISK ON SUDAN

1. FLOODING

Natural disasters in the contrasting forms of drought and flooding have historically occurred frequently in Sudan, and have contributed significantly to population displacement and the underdevelopment of the country. The floodplains however are a rich source of agricultural land. Traditional irrigation is concentrated on the floodplains of the main Nile downstream of Khartoum, but is also practiced over substantial areas along the White and Blue Nile and the Atbara river, as well as on the Gash and Tokar deltas. Crops are irrigated in three ways. The method most widely used is based on cultivation of quick maturing crops on the highly fertile lands (gerf) that are exposed following the withdrawal of annual floods. This technique capitalizes on the residual moisture in the soil profile that is available when the floodwaters recede.

Despite serious water shortages, floods are common in Sudan. The two predominant types of floods are localized floods caused by exceptionally heavy rains and run-off (flash floods), and widespread floods caused by overflow of the Nile and its tributaries.

Severe flash floods were recorded in 1962-1965, 1978-1979, 1988, 1994, 1998, 1999 and 2006. Though generally short in duration, these events can cause major damage to villages and urban and agricultural areas located in catchments and drainage zones. Nile floods usually originate from heavy rainfall in the (now largely deforested) catchment areas of the Ethiopian mountains, which causes unpredictable surges in the flow of the Blue Nile. The sequence of severe Nile floods – which were recorded in 1878, 1946, 1988, 1994, 1998 and 2006 – clearly shows that the frequency of flooding has increased dramatically over the last twenty years⁵⁷.

The Aswan High Dam, which was built in southern Egypt bordering the Sudan, significantly impacted on the lives of farmers downstream from the dam. When the river flooded once a year before the dam was built, it deposited fertile soil from upstream on its banks downstream. This washed up soil was extremely fertile, and renewed itself every year in the flood season. Since the dam was built, the annual flood has been stopped causing all the farmers downstream to have to use fertilizers to grow crops; this makes it more expensive. However it has also created a big water body – Lake Nuba (known as Lake Nasser in Egypt), which stretches back 500 km from the dam: 350 km in Egypt and 150 km in Sudan. Lake

⁵⁷. Government of the Sudan, 'Final Environment Report' prepared for the OSS Project, 2007.

Nuba has created a big fishing industry, which produces 25,000 tons of fish a year.

2. SOIL EROSION AND DEPOSITION OF SILT

Erosion of the banks of rivers affected the Roseires Dam in Sudan. The accumulation of silt in front of the power house intakes with its floating debris during the flood season restrict to a large extent the power generation and resulted in severe power shortage during the flood season.

The Merowe Dam is likely to have serious environmental impacts, these impacts include:

- Sedimentation of the reservoir due to massive erosion in Ethiopia, among other factors;
- Evaporation from the reservoir;
- Infestation of the reservoir by water hyacinths;
- Massive daily fluctuations of the water level downstream of the dam, with corresponding impacts on downstream agriculture;
- The spread of waterborne diseases.

The River Nile is a typical alluvial river. In Northern part of Sudan it passes through alluvial plains surrounded by an extended desert. Its banks and bed continuously experience a series of changes manifested in the form of meanders, narrow and wide channels, shallow and deep pools, flat and steep banks and slopes, rocky and silty beds, etc... and these are never permanent. These changes ultimately affect the cultivable areas. It is known that the cultivable area in the Northern region depends mainly on the Nile waters in irrigation. The Nile is prone to sedimentation, river widening and bank erosion leading to severe impacts on the agricultural activities in the areas (Figure 23).

Most of the irrigation schemes are now in poor condition suffering from sediment deposition in front of the intakes (inlet channels) of the pumps. Many of the pump stations were clogged and are now inoperative; others will follow affected by the steady propagation of the problem (there are approx. 130,000 ha under irrigation in Sudan). The history of this phenomenon does not go back to more than the last three decades when those changes were noticed in some schemes. The problem was aggravated in the last years due to increasing extraction of irrigation water upland together with natural decreasing river inflows.

The heavy silt load in the river mainly originates from the now largely denuded Ethiopian Highlands; the White Nile loses most of its silt in the great sud and over Ugandan territory. The Blue Nile and its tributaries and Atbara River, originating from the Ethiopian plateau, are the main source of sediment in the canalization systems, dams' reservoirs, and inlet channels of the pumping schemes. The problem of sedimentation in the Sudanese irrigated systems has been a serious one, and represents the major cause of water shortage in many parts of these systems, reducing the production and affecting the livelihood of the inhabitants of the scheme.

The total length of severely eroded banks is approximately 40 km., resulting in high economic



FIGURE 23: Erosion and Scouring at the river Nile banks (Sudan)

and environmental impacts. These impacts are manifested in loss of fertile agricultural lands, crops and high value perennial trees and dislocation of families and villages. Protection using revetments was found to be more stable and sustainable but because of the high cost involved; small reaches are now being protected.

The average sediment load entering the main canal in Gezira increased more than fivefold between 1933 and 1989, from 700 ppm to 3,800 ppm. It is estimated that 15 percent of the Gezira scheme is now out of production due to siltation.

Sedimentation of canals also leads to water stagnation and the emergence of weeds that provide an ideal habitat for the proliferation of water- and vector-borne diseases, in particular schistosomiasis and malaria. Chronic incidence of these diseases has been exceptionally high in the irrigation schemes.

3. COPING STRATEGIES

In Sudan, current major climate hazards consist of drought and extreme flooding events; there are other climate related phenomena such as dust storms, thunderstorms and heat waves whose occurrences, though less frequent, still pose serious threat to local livelihoods. Future climate change is expected to see these hazards intensify.

Sudan has been actively seeking to mainstream adaptation to climate change in the development process, by inclusion of climate and vulnerability in sectoral and development policies that are complementary to the climate change are environmental policies embodied in the 10-year Comprehensive National Strategy (1992-2002) and the 25-year comprehensive National Strategy Outlines. Key strategies include the Poverty Reduction Strategy; the Roll Back Malaria Programme; and Rainwater Harvesting⁵⁸.

The NAPA identifies several projects that will help the Sudan adopt itself better to climate change:

■ **Enhancing resilience to increasing rainfall variability through rangeland rehabilitation and water harvesting in the Butana area of Gedarif State:** As part of a past pilot project, a small dam was constructed in 1997 in the Wabi Abu Garod valley to capture and store rainfall run-off during the rainy season and make it available to meet irrigation and other needs. The successful experience of the dam thus far has been recognized by local communities as a significant contributor to building resilience against rainfall variability. Water harvesting techniques that are suitable relative to expected increased evapotranspiration from climate change would help reduce the vulnerability of communities in Batana area. The site was chosen because it is traditionally known as the most important communal grazing area for all tribes in the region.

■ **Reducing the vulnerability of communities in drought-prone areas of southern Darfur State through improved water harvesting practices:** Southern Darfur State is located in western Sudan and is inhabited by 3.8 million people (according to the 1993 census). Agriculture, which represents the basic livelihood in the State, has always been practiced in a very traditional way under diverse conditions of climate and soil. People grow staple as well as cash crops. However, they face the threat of crop reduction and crop failure due to the variability and continuous decrease in rainfall that has been recorded in the region since 1921. The rainfall isohyets are found to be moving southward. The main goal of the proposed project is to enhance the resilience of local communities in the drought-prone areas through water harvesting measures.

■ **Improving sustainable agricultural practices (Figure 24) under increasing heat-stress in the River Nile State:** The main goal of the proposed project is to reduce the vulnerability of farmers caused by the increase of temperature during the winter season.

■ **Environmental conservation and biodiversity restoration in northern Kordofan State as a coping mechanism for rangeland protection under conditions of increasing climate variability:** The main goal of the proposed project is the rehabilitation of vegetation cover and restoration of biological diversity to reduce the vulnerability of livestock following increased temperatures.

■ **Strategies to adapt to drought-induced water shortages in highly vulnerable areas in Central Equatorial State:** The main goal of the proposed project is to promote sustainable livelihoods in the Southern Equatorial State. Specifically, this involves the establishment of two micro-catchments to trap water.

⁵⁸. Government of Sudan, NAPA, 2007.

There are also a number of projects identified that are not of the same priority as the above⁵⁹.



⁵⁹. Government of Sudan, *ibid.*

ASSESSMENT OF FLOODING AND EROSION RISK ON UGANDA

1. INTRODUCTION

There are three basic types of drought: meteorological drought, hydrological drought and agricultural drought. According to the Meteorological Department of Uganda, any area with a mean annual rainfall less than 650 mm is characterized as a drought prone area. A prolonged period of below average precipitation, creating a situation of natural shortage of water supply leads to meteorological drought. Agricultural drought occurs when there is not enough moisture to support average crop production e.g. during the dry season in areas which normally produce crops, or pasture production on rangeland. Much as agricultural drought often occurs during dry, hot periods of low precipitation, it can also occur during periods of average precipitation when soil conditions or agricultural techniques require extra water.

Hydrological drought occurs when water reserves in aquifers, lakes and reservoirs fall below an established statistical average. Again, hydrological drought can happen even during times of average or above average precipitation if human demand for water is high and increased usage has lowered the water reserves.

Flood prone areas in Uganda include the low lying areas which consist of the cattle corridor; e.g. Nakasongola, Moroto, Kotido, river mouths and banks; R. Semliki, R. Manafwa, R. Katonga and areas which were once wetlands but have been converted to settlement areas due to increase in population e.g. the peri-urban areas of Kampala like Bwaise, Nateete and Nakivubo channel.

Flooding is a common problem in some of the lowland areas of Uganda and has also assumed serious problems in some of the highlands. A recent spate of landslides in the Mount Elgon area led to over 300 deaths and displaced hundreds. By September 2010, the people displaced from the foothills of Mount Elgon are yet to be resettled and the situation is still fragile as landslides are still leading to fatalities and displacement of yet more people. These floods are often followed by severe droughts which may lead to famines since crops were destroyed and the new planting seasons disrupted by the rains and displacement of the people.

Collection of data and study of the flood situation in Uganda has not been done conclusively. The present hydrological data collection network does not capture high flood flows

that would otherwise be used to facilitate calibration of the appropriate flood models. Nonetheless, DWRM has reported that flood modeling with MIKE Flood hydrologic model is being undertaken in the Lake Kyoga basin following the 2007 floods⁶⁰.



ibid

FIGURE 25: Flooding at a Kampala City suburb (2007)

2. COPING STRATEGIES

The NAPA of Uganda identified coping strategies for the country in their Report. The strategies are divided into categories:

- Exploitation of aquatic resources for those communities living near water bodies. The intensification of the frequency of droughts and famine compounds the exploitation of these resources. Once disaster strikes, fishing activities intensify as an alternative livelihood option particularly where arable land is scarce. Promotion of aquaculture is a distinct technology, which should be strengthened for coping with drought.
- Food preservation using innovative local techniques such as for example sun drying, use of herbal plants and ashes to store food, use of honey to preserve meat and smoking.
- Exploitation of herbal medicines from the rich diversity available for the treatment of diseases such as malaria, diarrhoea, wounds, worms, skin diseases, eye infections and coughs.
- Exploration of alternative livelihood systems such as charcoal burning, brick making, craft making, commercial motor cycling and hawking.
- Water harvesting from ponds, roof tops and runoff. On the communal scale, earth dams have been constructed to serve the community.
- Soil conservation by use of infiltration ditches around homes, planting grass cover, terrace farming, digging trenches to divert runoff, mulching and tree planting.
- Changes in husbandry practices such as watering animals earlier in the day during the dry season.
- Self-help initiatives through formation of self-help community emergency groups and/or extended family networks.
- Vector control using innovative methods such as cow dung smoke.

⁶⁰. Government of Uganda, Final Environment Report, prepared for the OSS Project.

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- Rural-urban migration where affected communities have no option for coping with climate-induced stress, especially in drought-prone areas then, victims migrate to urban areas or resource-endowed neighbourhoods.
 - Sale of assets and use of starter stock where the reserves are used up.
 - Encroachment on wetlands during droughts when rain-fed agriculture has failed. This destroys the wetlands thus changing the microclimate. Availability of water for agriculture on arable land is therefore a preferred solution to this practice.
 - Exploitation of forest and wildlife resources (e.g. wood, craft materials, medicine and foods) and services (microclimate moderation, sanitation, and water catchments). With increasing stress, exploitation of these resources is increasing.

A number of projects have been identified for implementation under the NAPA:

1. Community Tree Growing Project.
2. Land Degradation Management Project.
3. Strengthening Meteorological Services Project.
4. Community Water and Sanitation Project.
5. Water for Production Project.
6. Drought Adaptation Project.
7. Vectors, Pests and Disease Control Project.
8. Indigenous Knowledge (IK) and Natural Resources Management Project.
9. Climate Change and Development Planning Project.

ASSESSMENT OF WATER POLLUTION AND QUALITY ON DJIBOUTI

1. INTRODUCTION

The main water quality problem in Djibouti is salt water intrusion or mineralization of the groundwater. Since the country depends largely on groundwater sources for drinking (Figure 26) and other requirements, the problem is increasing as the groundwater sources are highly exploited. There has been a noted decrease in precipitation of 4.4% over the last few years and it is projected to decrease a further 11% up to 2050. This will in turn lead to the decrease of water infiltrated into the ground and the wadis to which most consumers turn to will not be recharged adequately.



FIGURE 26: Cattles drinking from the water source

The City of Djibouti, in which more than 65% of the population lives, depends to a large extent on the large aquifer that is recharged by rain infiltration; there is a grave danger that the reduction in rainfall and high evaporation (potential evaporation is 2,000 mm per year) will lead to critical shortage of potable water⁶¹.

2. SALINITY OF GROUNDWATER

The plain of Djibouti is located between fractured basalt Gulf and Somali basalts, is operated for supplying drinking water to the City of Djibouti by ONED with the help of a network of wells, much of which is located on the coastline, between Djibouti and Loyada. The area lies about 20 km south and west of the Capital. The groundwater recharge from infiltration occurs primarily during floods in wadis. The infiltration rate was estimated between 0.2 and 0.5 m per day over an area of 12 square km. Because of this proximity to the sea, the salinity of the wells is high. The most predominant minerals are sodium chloride the concentration is a total of about 800 to 900 mg/l. The correlation between the concentrations of chloride and distribution of drilling shows a concentration gradient towards the sea and a degree of zonation. The studies conducted by teams from the Centre for Studies and Research of Djibouti (CERD) show that the high salinity of the water in Djibouti has several origins. It is primarily from the intrusion of salt water of marine origin because of its proximity to the Coast. The second origin is the existence of fossil water whose salinity is high⁶².

Surface water in Djibouti is mostly from ephemeral (non-perennial) rivers but they provide a valuable source of water for the rural communities. Only 5% of the water is used while 92.5% is lost in evaporation owing to the high ambient temperatures and high potential evaporation. Runoff and infiltration to the ground constitutes the rest of the water from rainfall.

3. COPING WITH HIGHLY SALINE WATER IN DJIBOUTI

It was in this objective that programs of action in the water sector have been undertaken including:

- Replace or improve drilling of groundwater in Djibouti in order to improve the quality of water before salinity becomes too high;
- Improve the water supply to the town of Ali-Sabieh with the installation of a treatment plant and mineral water plant; the quality of water has become highly charged with sulphate;
- Ensure drinking water supply of the village at high altitude and the surrounding areas that have long suffered from lack of water;
- Replace the existing pumping equipment at some boreholes and create additional water points across the country equipped with solar systems to reduce recurrent costs associated with the operation of rural water points.

⁶¹. Government of the Republic of Djibouti, NAPA, 2007.

⁶². Ibid.

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- Agro-pastoral projects have been launched on emergency funds.

Other measures initiated by the Government with the support of its partners are in the fields of agriculture, livestock and forestry including the dissemination of appropriate technologies for water conservation, control of the development of irrigation techniques, building capacity of farmer organizations, construction/rehabilitation of infrastructure and irrigation systems, promotion of agricultural inputs and agricultural tools adapted, and introduction of small cattle or dairy farms at the periphery of urban centres. Other actions against pests or support for private initiatives have also been promoted by the Government and its partners in parallel with its efforts to improve the institutional and legal environment⁶³.

⁶³. Government of Djibouti, NAPA, 2007.

ASSESSMENT OF WATER POLLUTION AND QUALITY ON ETHIOPIA

1. INTRODUCTION

Pollution risk of water resources in Ethiopia is related to disposal and management of domestic, industrial and agricultural wastes (both solid and liquid). Although the latter two are at their infant stage, pollution of surface and ground water resources has been registered from these sources in many parts of the country. Furthermore, during the implementation of the PASDEP, the country entered in to a massive irrigation and industrial development with corresponding potential risk of surface and ground water pollution.

The main pollution channels are domestic wastes, agricultural effluents and agro-chemicals and industrial wastes.

2. DOMESTIC WASTE

It is common practice both in the rural and urban areas of the country to dispose solid and liquid waste in the open which eventually causes health problem and contaminates surface and groundwater sources. Groundwater supply sources are experiencing pollution due to contamination with sewage; identified and developed borehole sites are now within settlement centres due to expansion of towns which leads to increased pollution risk. At present there is no central sewerage system even for big cities like Addis Ababa.

The amount of wastewater from urban premises is increasing at an alarming rate in the recent years as a function of increased population and water supply coverage. The amount of water lost is dependent upon the standard of housing and the traditional water uses.

To date there hardly exist wastewater treatment facilities in the country and this situation is anticipated to remain the same at least for the coming few years. About 99% of the total domestic wastewater is simply disposed off in open ditches to surface waters. Most of the wastewater is seeped into the ground through pit latrines and soak pits, evaporates as sullage thrown onto the ground, or finds its way into watercourses by being disposed of into street drains. Wastewater treatment could be realized when wastewater is collected in a piped sewerage system to a central location for treatment and disposal which is not the

case even for Addis Ababa city.

3. AGRICULTURAL EFFLUENTS AND AGROCHEMICALS

The use of agrochemicals is essential for increasing crop production through improved soil fertility and pest control. However, there exists the risk of water pollution and impact on aquatic ecology due to uncontrolled release and contamination by residual agrochemicals of water bodies. Unless the necessary measures are implemented in the irrigation project planning, catastrophic impact may result in pollution of surface and ground water resources.

The present rate of fertilizer and pesticides application in Ethiopia is low; however there is a steady increase from year to year. UREA and DAP are the dominant fertilizers type used in Ethiopia.

The increase in fertilizer utilization came mainly due to the corresponding increase of land put under crop production. The average fertilizer application rate in the country is assumed to be about 75 kg/ha for the year 2006. The fertilizers are mostly used in the highland area for crop production which is major land use in the highlands. Crop production is not common in the lowlands and the plain areas since they continually receive top fertile soil and silt from the upper catchments areas.

The use of pesticides is more pronounced in the lowland area since the climatic and other factors are favourable for propagation of pests. Development of irrigation may provide moisture throughout the year hence the use of pesticides and corresponding risk of residual chemicals will be increased. According to information on registered agrochemicals by MoARD, there are 88 insecticides, 47 herbicides and 32 fungicides registered for utilization in Ethiopia. Herbicides constitute about 56% of the total agrochemicals imported into the country. Generally, import and utilization of pesticides increase from year to year. It increased from 1016M/T in 2000 to 3,328M/T by 2006.

Nutrient concentration of surface and ground water source could be increased through leaching of residual agrochemicals. Concentration of nutrients in lakes is increasing which could be related to increased residual agrochemicals and sediment in runoff generated from the highlands. The present application rate is assumed to be too low to cause pollution of surface and ground water quality of the country in general⁶⁴.

4. INDUSTRIAL WASTES

Industrialisation is increasing rapidly in Ethiopia, with at least 200 new industries being registered in 2007/7, representing a 16% increase over the previous year. Industrialisation is directly related to corresponding increase in industrial water demand and the amount and type of pollutant in the air, water and soil. The total number of large and medium scale manufacturing establishments for the country as a whole for the year 2006/7 was found out to be 1,443. The major industrial facilities according to their abundance is manufacture

⁶⁴. Government of Ethiopia, Final Environment Report, prepared for the SSO Project, 2009.

of food products and beverages, non-metallic mineral products, furniture, paper and paper production, tanneries, chemicals, rubber and plastics and textiles⁶⁵. Manufacture of food products and beverages and of textiles contribute about 50% of the total employment provided by the whole manufacturing sector. About 51% of the industries in the country are located in and around Addis Ababa from which the main catchment is the River Awash.

The major industrial wastewater sources in Ethiopia are from the food and beverages, tanneries and leather, textile, pulp and paper, chemicals, metal & non-metals, tobacco and wood industries.

5. SOIL POLLUTION AND SALINITY EFFECTS

Water logging and salinisation of soils are common problems that are linked with surface irrigation application method. On irrigated land, salinisation is the major cause of land and the most significant adverse environmental impact associated with irrigation development. It has been estimated that that annually irrigation takes out of production as much land as it puts in because of soil deterioration, principally salinisation. Water logging results primarily from inadequate drainage and over-irrigation and to a lesser extent from seepage from canals and ditches.

The problem is more severe in the lowlands where there is higher evaporation and in saline soils. Soils which are characterized by high sodium accumulation cover about 495 km² of the country's surface area. Water logging concentrates salts that are drawn up from lower in the soil profile in the plants root zone. Alkalinization (build up sodium in soils) is a particular detrimental form of salinisation which is difficult to rectify. In Ethiopia the causes of salinisation and alkalinisation are both of natural and human induced origin. Excessive irrigation, poorly designed or insufficient drainage structures are the major causes.

There are a number of solutions to minimize/avoid or rehabilitate these lands that include proper irrigation drainage system, leaching of salts, efficient irrigation management, deep ploughing and planting, application of gypsum and use of various biological practices. One or more of these physical, chemical and biological measures could be applied to reclaim affected soils. Water logging and salinisation can also be reduced or minimized by adopting pressurized (sprinkler and drip) irrigation methods. These irrigation application methods apply water more precisely that corresponds to required limits for the crop. There is no data to describe the salinisation of land due to modern and traditional irrigation practice in the country. Professional observation and experience in various parts of the country showed development of salinisation and loss of land productivity.

Pollution of soil may be resulted by accumulation of salts in soils leading to irreversible damage to the soil structure. The effects are more extreme in clay soil where the presence of sodium can bring about soil structure collapse. There is no comprehensive data to describe the extent of soil pollution in the country⁶⁶.

⁶⁵. Ibid.

⁶⁶. Ibid.

Wastewater from irrigation fields comes out of agricultural fields which are rich in salts and agrochemicals and other pollutants leached out from the irrigation fields. To date there is no irrigation project with treatment facilities (attenuation ponds) to treat wastewater coming out of irrigation fields and before it is released to receiving environment. As a result, the receiving lakes and rivers and groundwater are continually polluted with consequent impact on social and ecological wellbeing.

Surface irrigation uses more water than drip irrigation and leads to higher impacts on the environment. However, surface irrigation will remain the main irrigation method in Ethiopia over the short and even the long term since it uses simpler technologies and is easily adaptable.

The amounts of wastewater significantly vary with method of irrigation to be adopted; normally surface irrigation method produces the highest amounts while drainage water in drip irrigation systems are considered insignificant. The most acceptable recommendation to mitigate impacts related to drainage water is to reduce the wastewater generated and establish treatment facilities (physical/biological). For this purpose irrigation development that focuses more on pressurized irrigation (drip/sprinkler) would be required. The overall benefit from pressurized irrigation system is far more although the system has limitation such as heavy investment cost and specific crop selection. Wastewater from irrigation fields could be significantly reduced if pressurized systems are introduced.

ASSESSMENT OF WATER POLLUTION AND QUALITY ON KENYA

1. INTRODUCTION

Generally water resources are under pressure from agricultural chemicals and urban and industrial wastes, as well as from use for hydroelectric power in Kenya. The country expects shortage of water to pose a problem in the near future due to high population increase, wastage and under investments in the sub-sector. Water quality problems in lakes, including water hyacinth infestation in Lake Victoria, have contributed to a substantial decline in fishery output and endangered fish species.

Inadequate access to improved water and sanitation is causing deaths and other illnesses. With an access rate of 61% to improved water and 43% to improved sanitation, approximately 60% of Kenya's hospital attendance is due to preventable diseases of which 50% are related to sanitation, hygiene and water.

2. MAIN CAUSES OF POLLUTION

The main pollutants resulting from human impacts in Kenya are:-

- Organic residues from municipal sewage, brewery wastes, wet coffee processing wastes, sugar cane milling, pulp and paper milling and creameries.
- Toxic wastes from heavy metals, pesticide discharges and tanneries.
- Fertilizers from agricultural activities (Fig. 27).
- Detergents from domestic use.
- Micro-organisms from municipal sewage.
- Inert suspensions from soil sediments and mine waste.

3. GROUNDWATER POLLUTION

Groundwater in the Western, Central, Nyanza and Nairobi Provinces contain little dissolved solids and consequently low electric conductivity. Salinity increases with decreasing rainfall and little recharge. As a result groundwater in North Eastern Provinces is more saline due to sea water intrusion along the coast and evaporates deposits inland. In areas of high rainfall



FIGURE 27: Flower firms, pastoralists and water pollution

in central Kenya and coastal region, the water is mainly bicarbonate with a dry residue below 1,500 mg/l; this water can be classified as “good”. In the areas with little rainfall in the north and east, chlorides predominate and the salinity is much higher. This water is classified as “unfit” for human consumption.

Groundwater in Nairobi, North Eastern and Rift Valley Provinces and isolated parts of Lake Victoria has exceptionally high fluoride content exceeding the WHO drinking-water guideline value of 1.5 mg/l. The fluoride content can be as high as 6.3 mg/l and 3.4 mg/l respectively in Lake Victoria and Athi River basins.

Bacteriological contamination occurs in areas with high water table such as Kano Plains, Wajir and Mombasa and in densely settled areas⁶⁷.

Agricultural sediments often contain agrochemicals and if discharged into water bodies through erosion pose real threats to these reservoirs and the life they support. Sedimentation reduces reservoir water holding capacity, which can translate into reduced hydro-power generation and hence power rationing as has been witnessed in Kenya in the recent past. Eutrophication as indicated by algae blooms and proliferation of seaweeds is of particular concern to limnologists. The environmental and socioeconomic costs of eutrophication in

⁶⁷. Government of Kenya, Final Water Resources Report prepared for the OSS Project, Dec. 2009.

Kenya are exemplified by the water hyacinth and sylvania weed problems in lakes Victoria and Naivasha. Other widespread forms of water pollution in both rural and urban areas of Kenya include the disposal of dead animals and plant matter, faecal pollutants, domestic-wash and kitchen wastes, and sewage into water bodies⁶⁸.

4. SEWERAGE AND SANITATION

Cases of pollution are exemplified by outbreaks of typhoid and other bacterial diseases, viruses, protozoa and helminthes. Typhoid is an enteric disease caused by a bacterium (*Salmonella typhi*) that is transmitted through consuming or getting in touch with water containing the etiologic agent. There is also gas gangrene caused by *Clostridium perfringens*, amoebiasis caused by *Entamoeba histolytica* and lately in Kenya there was an outbreak of leptospirosis, in Bungoma caused by *Leptospira* spp. Faecal pollution of water bodies is also common from domestic and sewerage units in the towns.

Most of the sewerage systems in Kenya are not supposed to combine with storm water runoff. There is however a lot of inevitable mixing between the two. In the slum areas of Kibera, Mathare and Ngomongo in Nairobi, storm water joins the sewage directly and they all run into the streams or to the sewage treatment plant. The types of pollutants contained in the storm water runoff will depend on materials left on soil surfaces that can be carried downstream or in to sewerage systems. Since in most cities in Kenya there is a lot of small-scale repair and manufacturing of products (Jua Kali), metal pieces will be carried in storm waters. The metals will include Fe, Pb, Mg and Cd. These pollutants may end up in the food chain and affect aquatic life. There will be some level of N₂ dissolved in rainwater from the atmosphere. Phosphorus, carbon and other suspended solids will also be in rainwater.

There are 142 gazetted urban centres in Kenya of which only 30% have sewerage systems. This has posed serious environmental and health problems. Main sewer systems in most urban centres suffer from constant breakage or leakage and inadequate capacity to handle their full sewerage load. A number of factories and enterprises discharge effluents through mainstream rivers and valley depressions causing high pollution levels. Effluent pollution makes rivers, streams and dam water unsafe for domestic and livestock consumption. The use of pit latrines and septic tanks is common and in some areas where the central sewerage system has failed, the local authorities are recommending the use of septic tanks and pit latrines, which pollute the groundwater.

Wastewater management in informal settlements in Kenya is deplorable. Kibera, which is the largest informal settlement in Nairobi city covering an area of 225 hectares, has traditional pit latrines as the only excreta disposal system available, and a high proportion of households have no toilet within or close to their home. There are often up to 200 persons per latrine. Pits fill up quickly and emptying is a problem because of poor accessibility. Space to dig new pits is often not available.

Poor farming methods such as the intensive use of fertilizers for enhanced crop production, farming along the river banks, poor siting of cattle dips and overgrazing/over-browsing by livestock along catchment areas, have led to soil erosion and increased nutrient loads and

⁶⁸. Government of Kenya, Final Environmental Report, prepared for the OSS Project, Dec. 2009.

siltation of water bodies⁶⁹.

5. LAWS AND REGULATIONS TO CONTROL WATER POLLUTION

Kenya has enacted laws and regulations to regulate the discharge of wastewater and solid wastes into the environment. The Environmental Management and Coordination Act (EMCA) of 1999 established a standards and enforcement review committee, which advises the Authority. The functions of the Authority include:

- Establish criteria and procedures for the measurement of water quality;
- Recommend minimum water quality standards for all the waters of Kenya and for different uses including water for drinking, industrial, agricultural, recreational, fisheries and wildlife and other prescribed water use;
- Analyze and submit conditions for discharge of effluents into the environment;
- Prepare and recommend guidelines or regulations for the preservation of fishing areas, aquatic areas, water resources and reservoirs and other areas where water may need special protection;
- Identify areas of research on the effects of water pollution on the environment, human beings, flora and fauna;
- Advise the authority to carry out investigations and steps necessary to abate water pollution;
- Document the analytical methods and appoint laboratories for which water quality and pollution control standards can be determined;
- Collect, maintain and interpret data from industries and local authorities on the pre-treatment nature and levels of effluents;
- Recommend measures and works necessary for the treatment of effluents before being discharged into the sewerage and water; and
- Submit to the Director-General as may appear necessary for the monitoring and control of water pollution.

Also EMCA:

- Prohibits pollution of water by discharges or applying any poison, toxic, noxious or obstructing matter, radioactive waste or other pollutants or discharge such matter into the aquatic environment in contravention of water pollution standards;
- Compels all owners or operators of irrigation project schemes, sewerage systems, industrial production workshops or any other undertaking to supply accurate information about quantity and quality of such effluents or other pollutants to the Authority;
- Effluents to be discharged only into sewerage system and the relevant local authority operating or supervising such sewerage system shall issue, at a prescribed fee, the necessary licence for discharge; and
- The Authority shall issue licence to discharge effluents.

⁶⁹ Government of Kenya, Final Environment Report, prepared for the OSS Project, Dec. 2009.

The actualization of the standards and enforcement review committee have, however, been hampered by capacity constraints (institutional, technical and financial). Further, perceived conflicts in institutional mandates (e.g. between WRMA and NEMA) especially at implementation levels hinders effective monitoring of effluent discharge.

Other laws and regulations relevant to pollution control are the Public Health Act; the Local Government Act and the Physical Planning Act of the laws of Kenya. However, implementation of the laws is problematic owing to weak institutional capacity in Kenya⁷⁰.

⁷⁰. Ibid.

ASSESSMENT OF WATER POLLUTION AND QUALITY ON SUDAN

1. DRINKING WATER

Sudan has sufficient natural water resources in the form of rivers, lakes, seasonal streams and groundwater to supply drinking water for the population in virtually all areas, except for some parts of the northern desert.

The constraint in supplying adequate and safe drinking water is principally due to a lack of extraction and purification infrastructure. Underinvestment and poverty are core obstacles for the supply of water throughout Sudan, and historical and current conflicts have exacerbated the problem. Water availability for agriculture and industry (which can use over twenty times the amount required per capita for potable purposes) is much more limited, and constrained by the scale and reliability of the resources rather than just underinvestment.

However, in a number of groundwater abstraction points, wells have dried up, such as in Darfur state where five of 12 wells dried up in one year (2006), indicating a substantial drop in the water table⁷¹.

2. SEDIMENT LOAD

Most of the major irrigation schemes have been seriously affected by heavy siltation in canals, a process that is accentuated by upstream watershed degradation. For example, the average sediment load entering the main canal in Gezira increased more than fivefold between 1933 and 1989, from 700 ppm to 3,800 ppm. It is estimated that 15% of the Gezira scheme is now out of production due to siltation.

Sedimentation of canals also leads to water stagnation and the emergence of weeds that provide an ideal habitat for the proliferation of water- and vector-borne diseases, in particular schistosomiasis and malaria. Chronic incidence of these diseases has been exceptionally high in the irrigation schemes. Due to the nature of the heavy clay cracking soils, the two major problems of soil salinization and water logging typically associated with irrigated agriculture are not prevalent in Sudan's schemes. Nevertheless, there is reportedly significant salinization at local levels in the drier north-western reaches of the Gezira near Khartoum, as well as in the Guneid sugar scheme. Monoculture farming and

⁷¹. Government of Sudan, Final Environment Report prepared by the OSS Project.

poor implementation of crop rotation has also led to deterioration in soil fertility and a significant decline in yields.

3. SOURCES OF POLLUTION

3.1. Internally displaced people (idp) camps

The concentration of a large number of people in temporary dwellings raises concerns for sanitation and bacteriological contamination of surface and groundwater. The standard solution is the construction of pit latrines, though these are not in place everywhere (this is particularly the case for IDP camps). The most severe pollution problems were observed in IDP camps in the more humid regions of Sudan. UNEP field teams (2006) found major water pollution issues surrounding all informal camps visited in Southern Sudan. These same areas were epicentres for the cholera epidemic of 2006.

3.2. Pesticides

A total of over 200 pesticides active ingredients are registered in Sudan either singly or in combination in over 600 different formulations. Almost 20% are used for mosquito control and other public health purposes. The remaining 80% are used for control of cotton pests and other rotation crops, besides considerable amounts used for the control desert locust, birds and rodents.

3.3. Water pollution

Water pollution threat comes from herbicides and insecticides, which are applied in the riverside agricultural schemes and are washed into the river by irrigation canals. The pesticides or the residue and degradation products can contaminate the water (re)sources from the formulating sites, fallout from the spray, washing from contaminated clothes, empty containers, application equipment and dumping of the surplus. Serious contamination has been detected in the Gezira canals as well as in boreholes in the Qurashi area (Hassahessa Province) and the Kassala horticulture area. Fertilizers containing inorganic nitrogen as well as waste containing organic nitrogen are the two main sources of frequently reported nitrate and nitrite contamination in groundwater.

Effluents of sugar factories are often discharged untreated into the river, creating a pollution hazard.

3.4. Sanitation and sewage

Problems with sanitation are evident throughout Sudan, where inadequate facilities are the norm rather than the exception outside metropolitan Khartoum. Village fringes, disused lots and seasonal watercourses are commonly used as open toilets, with predictable health consequences. Sanitation issues are most apparent in displaced persons settlements that have not been reached by international aid efforts. Such settlements are typically found on the outskirts of towns, and are generally very crowded and unsanitary.

Large scale aid-organized camps are usually in better condition but often face major challenges due to crowding and poor location. Sewage systems have been installed in Khartoum, but these facilities, which cover only a quarter of the population, are now massively overstretched and not functioning properly. As a result, a large amount of untreated sewage is pumped back into the Nile, with obvious health implications for downstream communities. Most other cities have some form of sewerage system but no treatment, so that effluent is discharged directly into the nearest watercourse.

In the very dry areas and in towns without a sewage network, the standard solution for the more affluent communities (including the international aid community) is to use a septic tank. When tanks are full, they are emptied by a suction tanker and the contents are dumped, usually in the dry bed of a local seasonal watercourse. This process is particularly inequitable as it essentially transfers the waterborne disease risk from the affluent to the poor, who take their water from such water resources.

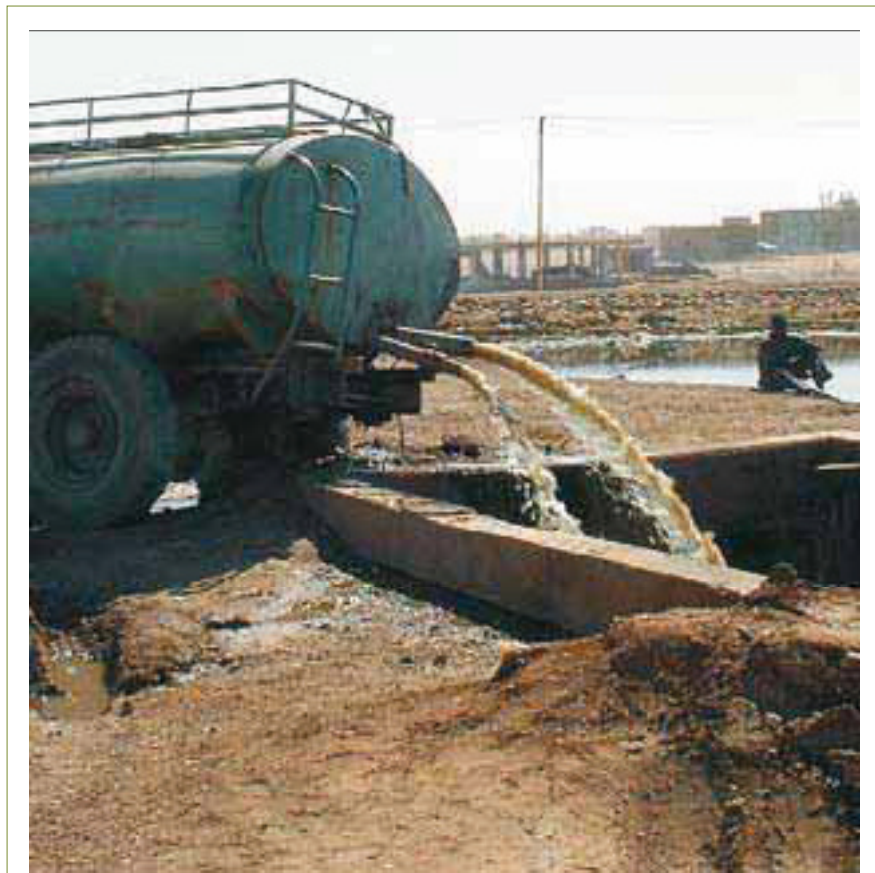


FIGURE 28: Emptying a truck full of sewage into the Khartoum Sewage Works.

Government of Sudan, ibid.

3.5. Impact of oil production

The generic environmental impacts and risks associated with the oil industry include various contaminating materials through all the stages of oil exploitation. Oil exploration processes have the greatest impact on the environment of all the phases of oil production, due to the

large areas affected and the temporary nature of the work. Exploration is unsuccessful in over 90% of cases, and when the results are negative, oil companies abandon the areas surveyed. The most significant of these impacts are access roads for very heavy equipment, seismic survey lines and drilling sites. The damage is mainly physical, comprising deforestation and de-vegetation, erosion and watercourse siltation and disrupted drainage patterns.

One of the most significant environmental issues for crude oil production facilities in Sudan is the disposal of produced water. Produced water is the water extracted from the reservoir along with crude oil, and separated from it before the oil is transported via pipeline. The volume of water can be very large, particularly in the later years of production, when the wells tend to produce more water and less oil as reservoirs become depleted. The Heglig facility alone currently generates over ten million cubic meters of produced water annually. Full production of the central Sudan fields in ten years time may yield five to twenty times that amount. Appropriate treatment and disposal options exist for produced water, but they can be costly. In the absence of regulations, it is unfortunately common practice around the world to simply discharge it to the nearest watercourse.

Produced water contains an array of substances such as mineral salts; dissolved and insoluble hydrocarbons; heavy metals such as cadmium, mercury and lead; aromatics, phenols, cyanides and other chemicals. Some of these occur naturally and come out from the reservoir. Others are «treatment chemicals» which are added during various stages of oil production. Treatment chemicals are added to the crude oil for various reasons, e.g. (i) to depress the pour point of crude oil, (ii) to make separation of accompanying water more efficient (iii) to prevent scaling and inhibit corrosion of pipeline.

Another pollution problem with the oil industry is the oil spill risk. There are two main sources of risk for oil spills arising from export operations in the Red Sea. The first is the process of loading the ships from the shore; the second is the navigation of the loaded tankers through the Red Sea. Spills associated with loading have occurred, but have apparently been very minor. Navigation of the loaded and empty tankers in the Red Sea presents navigational hazards in the form of over 1,000 very small islands, sandbars and shallow submerged coral reefs. Much of the coastline is fringed by reefs and there are few safe havens able to take large vessels. In addition, the presence of coral reefs and sea grass beds makes the Red Sea highly sensitive to pollution.

3.6. Waterborne diseases

The shortcomings in water quality and sanitation in Sudan are directly reflected in the incidence of waterborne diseases, which make up 80% of reported diseases in the country. The incidence of disease is highly seasonal: the greatest problems usually occur at the start of the wet season as the rains and run-off mobilizes the faecal matter and pollution that have accumulated during the dry season. The very limited water monitoring that has been carried out has confirmed bacteriological contamination of the Nile in Khartoum State and elsewhere in northern Sudan. Limited groundwater monitoring in metropolitan Khartoum also confirmed bacteriological contamination (Figure 29).

There is no sufficient data for Southern Sudan. Apart from the routine waterborne illnesses

such as cholera, dysentery, hepatitis A and a range of parasitic infections like schistosomiasis, a number of tropical diseases including malaria, sleeping sickness, river blindness, guinea worm and visceral leishmaniasis are still prevalent. Southern Sudan is particularly afflicted, with an estimated 70% of the world's cases of guinea worm occurring there. In 2005 and 2006, Southern Sudan experienced a major cholera outbreak in several cities including Yei, Juba, Bor and Malakal. The total number of victims recorded by WHO were over 16,000, with over 470 deaths. A UNEP team in 2006 visited one of the epicentres of an outbreak in Juba in February 2006, and found that water and sanitation problems were so severe and endemic that it would have been very difficult to pinpoint a single source, though according to WHO, untreated water from the White Nile and shallow open wells were the most likely suspects.

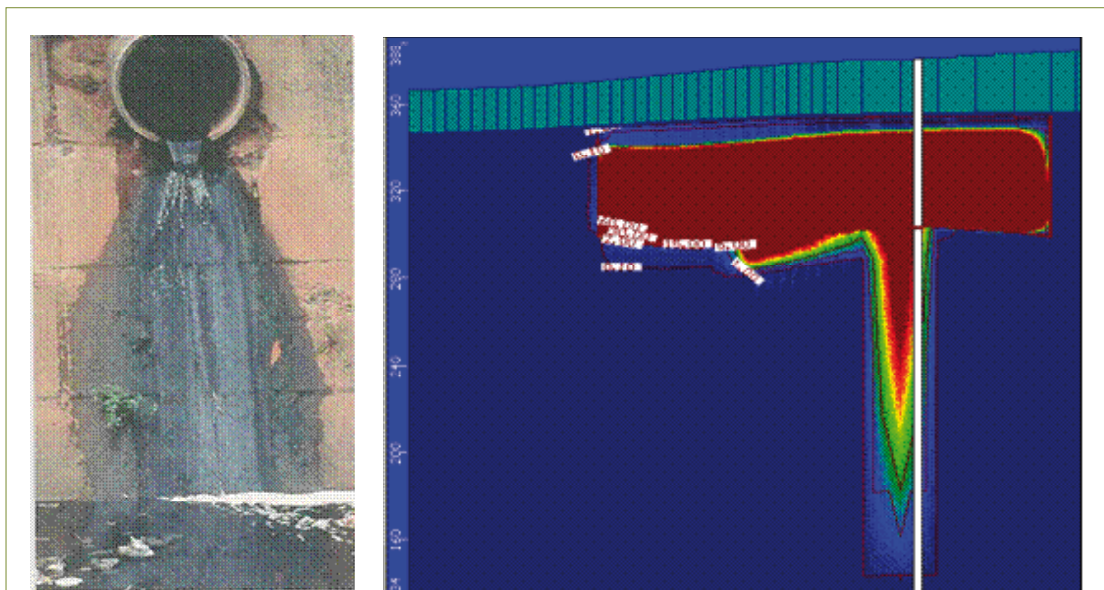


FIGURE 29: Surface and groundwater pollution by waste water.

ASSESSMENT OF WATER POLLUTION AND QUALITY IN UGANDA

1. INTRODUCTION

Uganda is endowed with appreciable water resources with the per capita renewable fresh water at 1,300 m³ per year. The water is mostly used in its raw form, except for the few groundwater sources (mainly boreholes – which require little or no treatment) and the large urban centres under the National Water and Sewerage Corporation, a state utility, which mainly treats surface water for its consumers.

Livestock and wildlife consume water in its raw form from the different sources, including valley dams which have been constructed to supplement the naturally occurring water sources, most especially, in the cattle corridor⁷².

2. POLLUTION FROM POINT SOURCES

The point sources which are responsible for pollution and waste discharge into the water resources of Uganda are comprised of municipal and industrial establishments.

Municipal water pollution consists of wastewater from homes and commercial establishments. The characteristics of industrial wastewaters differ considerably both within and among industries. According to National Water and Sewerage Corporation (NWSC), it is estimated that 100% of water supplied to industries is discharged back to the water bodies as wastewater and 75% of the water supplied for domestic use is discharged to the environment. However, only 25% of the wastewater in Kampala reaches the NWSC sewer system to undergo treatment before discharge to the environment. Since most of the Ugandan industries are agro based, their wastewater contains a lot of organic matter. This explains the high build-up of the biochemical oxygen demand (BOD) in the water bodies, particularly, in areas close to discharge points. A case in point is the Murchison Bay and the Napoleon Gulf on Lake Victoria which receive wastewater from the East African Breweries Limited and urban storm water through the Nakivubo Channel respectively. Both are heavily polluted and are also the source of water for the 3 treatment plants that serve Kampala City.

The industrial waste water also contains phosphorus in form of phosphates and nitrogen in form of nitrates which are responsible for nutrient enrichment of the water bodies leading to eutrophication. This has consequently led to the presence of frequent algal blooms in the

⁷². Government of Uganda, the Final Environment Report prepared for the OSS Project, 2009.

bays of Lake Victoria waters.

In Uganda only a small amount of wastewater is treated in industrial-scale wastewater treatment plants. NWSC operates sewerage systems in 14 of the 22 towns under its jurisdiction. Only Kampala and Masaka towns have conventional municipal wastewater treatment facilities. The rest of the 12 towns operate waste stabilization ponds. These mainly treat municipal wastewater/sewage. A small amount of wastewater is also treated using ecological approaches such as reed bed systems and constructed wetlands as tertiary treatment facilities.

The use of septic tanks and other On-Site Sewage Facilities is widespread in peri urban areas and serve a sizable number of homes. When these septic tanks are emptied, the waste is taken to NWSC plants for treatment before it is discharged into the environment. A few industrial plants have onsite facilities to treat their wastewater to a level where pollutant concentrations in the effluent complies with national effluent standards.

3. POLLUTION FROM NON-POINT SOURCES

In Uganda, run-off from agricultural farms (mainly livestock and poultry farming), urban storm water like in Kampala and rangelands are the sources of many organic and inorganic pollutants in surface waters and groundwater. The runoff carries both sediment eroded from cropland, and phosphorus and nitrogen that partly originate in animal wastes and commercial fertilizers.

4. ROLE OF WETLANDS

Pollution loads from both point and non-point sources, though huge, have not tremendously impacted on the water bodies with the exception of Lake Victoria. This is because of the natural wetlands that surround most of these water bodies. Wetlands play a vital role of cleansing the water before it enters the lakes; hence, not all of the pollution loads from non-point and point sources directly enter the water bodies. However, these wetlands are facing a lot of pressure mainly from solid waste dumping, nutrient overload and encroachment by people in need of land for both cultivation and settlement. This has led to degradation and shrinking of most wetlands and consequently leading to reduction in the performance of their important hydrological function.

5. GROUNDWATER POLLUTION

Although national water quality reports indicate that Uganda's groundwater quality ranges from good to excellent, localized incidences of significant groundwater contamination do occur. Water from deep wells is generally good except in some isolated cases and localized areas e.g. Rakai where the ground water is highly mineralized with high iron content which makes the water yellow on exposure to air, rendering it unusable for domestic purposes. In the Kyoga basin and Tororo, the groundwater is highly corrosive which makes the process of water production very costly. The highest mineral pollution of groundwater has been

registered at the base of Mt Ruwenzori in Kasese. This may partly be attributed to the mining activities in the area although this has not been proved yet since some studies have shown that upstream of mines, groundwater is highly mineralized as well.

Faecal pollution is the most common form of groundwater contamination in Uganda. It mainly occurs in unplanned settlements especially in peri urban areas of Kampala e.g., Bwaise, Mulago, Nateete and Kisenyi in Kampala. In these areas there are a number of springs that are being used as water sources yet they are heavily contaminated with faecal matter. The origin of the contamination is due to the high water tables and the population depends on pit latrines and septic tanks as a form of sanitation. The effluents of the shallow septic tanks and pit latrines easily find their way into groundwater bodies like springs and shallow wells.

Contamination has also been reported near hand pumped boreholes for domestic water supply. Leaking municipal landfills is another source of groundwater contamination.

6. SOLID WASTE DISPOSAL

Centralised solid waste collection, storage and disposal at the municipal level are practiced in most of the large urban centres; however, the system only covers the central business districts and the landfills are often poorly managed. About 10% of the solid waste generated enters and accumulates in the environment annually. In the rural and peri-urban settings, household waste is buried, burned, or just thrown away; the vegetable waste is often reused as feed for animals or composted for manure. Non-biodegradable waste is the most difficult to dispose off and tends to accumulate in the environment.

The Government of Uganda is engaged in a scheme aimed at reducing carbon emissions into the atmosphere by decomposition of organic waste to useful manure. This scheme is an initiative of the United Nations through the UN Carbon Fund. 18 towns have been earmarked for this scheme, eight of which have already implemented it. These include Jinja, Mbale, Soroti, Lira, Gulu, Masaka, Mbarara and Kabale towns. Unfortunately, Kampala which has got the highest amount of solid waste is not among the first towns to implement this scheme but, will, however get on board during the second round of implementation.

Disposal of solid waste is a major problem in Kampala as the main garbage site at Kiteezi is full and has been turned into a residential neighbourhood. Leaching of waste into the streams, foul odours, flies and rodents are major problems in the area as are the dust kicked up by the trucks delivering waste to the site. Acquisition of new garbage sites has met with difficulties since the population is not willing to have a (poorly managed) garbage site in their area.

7. WATER QUALITY OF LAKES AND RIVERS

Uganda's lakes are classified as shallow lakes; they are valuable conservation refuges for unique plant and animal species. They are valued for their unique genetic diversity, cultural and spiritual importance, scientific interest, recreational opportunities and intrinsic value.

Because of their shallow characteristic they are susceptible to eutrophication due to strong water-land, air-water and water-sediment interactions.

The eutrophication process and algal bloom formation is mainly influenced by phosphorus and nitrogen enrichment of water bodies. Nutrient enrichment in shallow lakes tells about the ability of a lake to support native plants and animal life and identifies long-term trends in water quality.

Lack of measured data notwithstanding increased eutrophication has been observed in most of Uganda lakes manifesting through the rampant algal blooms and fish kills. The algal blooms have affected aquatic life (ecosystem) and in cases hindered navigation and leisure activities such as swimming as a result of formation of a thick layer of algae as evidently seen in the Napoleon Gulf and Murchison Bay of Lake Victoria. It has increased water treatment costs by four folds and consequently leading to hiking of water tariffs.

Besides phosphorus and nitrogen enrichment, continued loading of BOD has increased the susceptibility of aquatic life as it promotes competition for oxygen between living organisms and decaying organic matter within the water bodies. Proliferation of invasive water weeds such as the water hyacinth has had multiple serious impacts on Uganda's water resources.

ASSESSMENT OF DROUGHT AND DESERTIFICATION ON THE SUB-REGIONAL LEVEL

1. INTRODUCTION

Large areas of the IGAD sub region are arid, semi-arid or desert with more than 50% of their land mass regarded as arid or semi-arid in some of the countries. The impacts of climate change and variability is therefore felt directly by these countries, especially the most vulnerable rural populations. The arid and semi-arid lands (ASALs) are mainly inhabited by the itinerant pastoralists and nomads, some of who combine pastoralism with agriculture. However their habitats are being denuded of vegetation – especially the forests – leading to wider environmental impacts such as land degradation, reduction in ground and surface water resources, pollution of the soils and waters, increased soil erosion and failure by the ecosystems to perform their roles in a sustainable manner.

The rapid population growth and poor socioeconomic structures in these countries make the future bleak for the vulnerable populations. In the case of Somalia, the extended civil conflict and the devastating flash floods combine to wreak havoc on the helpless population in the rural areas. Even the more peaceful north suffers from the flash floods which strike even after little rains due to the inability of the soils and terrain to absorb and retain rainwater.

The following sections give coping strategies that may be adopted in the region to combat climate change and variability.

2. GUIDING PRINCIPLES FOR CONCERTED ENVIRONMENTAL ACTIONS TO COMBAT CLIMATE CHANGE

The guiding principles for concerted cooperation on environment to combat climate change include⁷³:

- Climate change adaptation measures are primary while mitigation measures are secondary;
- Prioritization of regions, sectors and communities that are more vulnerable to climate change impacts in the policy implementation;

⁷³. EAC, 2010: East African Community Climate Change Policy.

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- Mainstreaming climate change issues into national development plans;
 - Climate Change adaptation and mitigation actions be carried out without compromising social and economic development; and
 - Partnership, collaboration and synergies among various stakeholders involved in Climate Change issues.

The emphasis of the regional actions is on adaptation rather than mitigation of the impacts of climate change.

3. ISSUES TO BE ADDRESSED TO ENABLE EFFECTIVE IMPLEMENTATION OF ADAPTATION ACTIVITIES

Key issues to be addressed to enable the region to effectively implement adaptation activities include:

- **Financing adaptation activities:** Increasing capacity to fund adaptation activities;
- **Responding to extreme weather conditions and related disasters:** Availability of adequate information, early warning systems and technological capacity;
- **High Poverty levels:** Ability to adapt to extreme weather events and climate variability;
- **High vulnerability of the population:** Increase of income of most vulnerable groups, fragile ecosystems and poor infrastructure;
- **Pressure on Natural Resources:** promote sustainable utilization of natural resources, promotion of alternative livelihoods, minimization of migration, internal and cross-border conflicts, and displacement of the populations; and
- **Man-made and natural disasters:** Development of adequate disaster management responses.

4. KEY ACTIONS TO ADDRESS CLIMATE CHANGE

The IGAD sub region should adopt actions below for combating climate change impacts:

- Support development and implementation of climate related Disaster Risk Reduction and Management as an adaptation tool;
- Support vulnerability risk mapping on all sectors including social and economic impacts of climate change;
- Improve early warning systems and preparedness in the region to avert or minimize the adverse impacts of climate change;
- Support diversification of economies to reduce dependence on climate-sensitive sectors such agriculture and water and environment;
- Support implementation of National Adaptation Programmes of Action (NAPAs) as a short term measure to address Climate Change (immediate and urgent actions);

-
- Develop and implement a regional Climate Change response master plan within which medium to long term strategies of adaptation to climate change will be formulated; and
 - Establish and operationalize a Climate Change Adaptation Fund.

5. ENVIRONMENTAL POLICY ACTIONS

5.1. Water and environment sector

- Utilize integrated water resource management principles in managing its water resources;
- Support development and transfer of water and climate information and technology that support water conservation through natural resource planning support, data acquisition and management, technology innovation and transfer, partnerships and joint ventures;
- Promote regional and international cooperation for better water management and conflict prevention through trust and confidence building;
- Promote transfer and dissemination of efficient water technologies including recycling of wastewater;
- Improve water security by promoting investment in water storage facilities;
- Strengthen initiatives for conservation and management of lake and river basins;
- Promote rain water harvesting, protection of water wells and springs, and other water sources;
- Promote participation of the private sector, civil societies and women in management of water resources;
- Promote bulk water supply to ensure adequate and reliable water for production;
- Promote Public Private Sector partnership in regulated abstraction and distribution of water for domestic, industrial, agricultural production and energy; and
- Promote actions that reduce water pollution, including protection of water quality and aquatic habitats.

5.2. Agriculture sector (crop, livestock and fisheries)

- Promote sustainable land management practices including conservation agriculture and improved production systems as a way to adapt to Climate Change;
- Promote development and implementation of irrigation policies in IGAD member states;
- Promote practices and technologies for efficient utilization of water for irrigation, livestock and aquaculture;
- Promote agro-processing and use of agriculture food storage facilities and
- Promote efficient livestock production systems.

5.3. Wildlife sector

- Promote measures that preserve the ecosystem integrity of critical wildlife habitats and endangered species;
- Establish, promote, and/or protect wildlife migration corridors.

5.4. Coastal and marine ecosystems

- Undertake protective measures for Coastal and Marine ecosystems which are particularly vulnerable to climate change;
- Support measures to control sea-side erosion as result of rising sea water;
- Mobilize funds to construct walls at vulnerable points to minimize adverse impacts of sea level rise;
- Conserve coastal and marine habitats to promote development of protected area management systems; and
- Establish coastal ecosystem monitoring and surveillance systems.

5.5. Land use and soil protection actions

- Promote sustainable land-management practices, including sustainable farming and agro-forestry practices within the EAC region;
- Ensure sustainable land-management and productivity of the soils, through measures that enhance soil quality, inter alia, to prevent its erosion, deterioration of its physical, chemical, biological or economic properties;
- Upscale integrated nutrient management and soil and water conservation measures to enhance soil fertility;
- Promote actions that reduce land degradation and soil erosion especially in the fragile ecosystems such as mountainous areas, lake shores and riverbanks; and
- Facilitate formulation of integrated sustainable land management investment frameworks and land use policies and plans.

5.6. Forestry and wetlands

- i) Promote sustainable management of forests and wetlands in the region;
- ii) Promote alternative energy sources in order to reduce dependency on biomass for energy needs in both urban and rural areas;
- iii) Promote reforestation, afforestation and agroforestry;
- iv) Strengthen enforcement of laws and good governance of forests and wetlands;
- v) Promote collaborative forest management practices;
- vi) Promote improvement of agricultural productivity so as to avoid deforestation and encroachment on gazetted wetlands;

-
- vii) Strengthen capacity to monitor and manage forests and forest related activities;
 - viii) Promote and strengthen community based management practices;
 - ix) Promote non-timber forest products;
 - x) Promote biomass energy-efficiency technologies; and
 - xi) Promote participatory, integrated watershed management practices.

5.7. Tourism sector

- Develop all weather infrastructure to support tourism in the region while ensuring minimal damage to wildlife habitats;
- Develop and diversify tourism products which are not very sensitive to Climate Change;
- Devise mechanisms of improving local vulnerable population livelihoods from revenues generated from tourism industry;
- Develop park management practices which will enable wildlife to adapt to the changing climate.

5.8. Infrastructure

- Promote climate change integration in all planning and design of infrastructure;
- Build awareness and capacity of the architects and engineers to take into account Climate Change in their professional deliveries; and
- Revise and harmonise structural/building codes and standards taking into account the expected changes in climate.

6. STRATEGIC ENVIRONMENT ASSESSMENTS

An important coping strategy is the carrying out of strategic environment assessment (SEA) on key sectors of the countries.

Strategic Environment Assessment (SEA) is a systematic, on-going process for evaluating, at the earliest stage, the environmental quality and consequences, of alternative visions and development intentions incorporated in policy, planning or programme initiatives, to ensure full integration of relevant biophysical, economic, social and political considerations⁷⁴.

The main benefits of SEA are that it:

- Pro-actively informs stakeholders of forthcoming developments, plans and programs;
- Identifies the opportunities and constraints which the environment places on development; or vice versa
- Provides guidelines on how to ensure that development is within sustainable limits;
- Has the ability to integrate across areas, regions or sectors;

⁷⁴. EAC Transboundary EIA Guidelines, 2005.

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- Improves the way in which cumulative impacts are dealt with in environmental assessment, for example, through the use of thresholds and limits of acceptable change; and
 - Focuses on the maintenance and enhancement of a chosen level of environmental quality, rather than on minimizing individual impacts.
 - It aims to integrate the concept of sustainability into the formulation of plans and programs.

ASSESSMENT OF FLOODING AND EROSION RISK AT THE SUB-REGIONAL LEVEL

1. INTRODUCTION

Flooding is a very serious matter throughout the 7 IGAD countries. It manifests itself mostly in flash floods – which are short duration flood events that tend to wreak destruction in their path. The acuteness of the problem is worst in Somalia, Djibouti and Eritrea since these mostly arid countries with an ocean bordering them do not have many permanent streams, meaning that the vast majority of the channels are dry most of the year round. They only come to life during the short but intense rainfall that occurs in these areas.

The severity of flooding has increased in all the IGAD countries over the last few decades as a result of climate change and variability which makes rainfall become highly unpredictable.

Djibouti is one of the countries that do not have permanent stream; the few streams in the country are shallow channels where the community resorts to during the dry season. However, when there is a storm, most of the water runs off rapidly, leaving death and destruction in its wake. Because of the short reaches of these streams, the warning time for residents is too small and the support infrastructure for early warning, such as public announcers are missing or grossly inadequate.

The rains fall in the highlands along the borders of Djibouti with Somalia, Eritrea and Ethiopia. An early warning system based on the highlands would greatly improve the lead time the announcers would have in order to evacuate the people living on the most vulnerable valleys and dry river beds. These are the most useable lands for farming since they retain some of the moisture for much longer than the steep slopes. With the construction of temporary structures by the farmers, the stage is set for widespread uprooting of the weak shelters when the rains come.

The mitigation actions for these flash floods include the setting up of storage facilities for the rainwater in dams, rainwater harvesting tanks and by reducing the slopes of the hillsides. However, most of the people who cultivate in these areas are mixed pastoralists and farmers, meaning that when the weather favours either of their lifestyle, they may adopt it over the other, or practice both of them.

Eritrea is one of the countries that do not have permanent streams throughout the country. The depth of the land from the Red Sea is small such that the highlands running parallel to

the Red Sea provide the catchment for the small amounts of rainfall that falls in the region. Flash flooding is therefore a severe problem since the dry riverbeds provide the farmers and the pastoralists with valuable water and grass for their animals. However, when the rains fall on the highlands, the poorly absorbent soils (rock and gravel slopes) simply runoff the water into the dry riverbeds, which suddenly come to life with devastating impacts. The time for warning is too short meaning that the flash floods often leave a trail of death and destruction in their wake.

Increased land degradation, lack of agricultural extension services and an economy recovering from a war footing are some of the bottlenecks that must be addressed by the State in order to improve on the fight against flooding and erosion risk in Eritrea.

Mitigation actions include relocation of the people to higher ground either on a permanent basis or on a temporary basis with reliance on early warning systems. The areas where flooding and erosion occur often are however poorly developed, with high levels of poverty. This makes it difficult to reach these communities to deliver the early warnings before the flash floods strike.

Ethiopia is a hilly country and the floods are generated from the highlands and dissipate into the lowlands, where they can cause havoc. Flooding also may result in erosion of soils from the highlands and deposition of silt on the lowlands.

The frequency of flood and drought events in Kenya has increased over the last 30 years and affects large numbers of people. The increased occurrence of flooding is caused primarily by the degradation of forests and wetlands, leading to soil erosion and increased silt loading to the rivers.

In Sudan, two types of floods are common – the flooding of the River Nile, which affects those who live near the river banks and the flash floods, which occur following exceptionally heavy rainstorms. The former can be widespread while the latter may be localised. The flash floods cause damage to the villages and urban centres and are difficult to predict. The overflows of the Nile occur following heavy and sustained rainfalls in the Ethiopian Highlands.

In Uganda, flooding and erosion has become a major problem especially since environmental degradation has led to loss of vegetation cover. There is also rampant encroachment of people into the wetlands. This has led to loss of lives and property as the floods engulf habitations that were erected in the low lying wetlands. The urban sprawl of Kampala has been especially hard hit though flooding of major flatlands in the eastern Uganda Teso Districts has also been witnessed due to the El Niño weather phenomenon.

Flash flooding is quite common in Somalia due to the short reaches of the dry stream beds. With hardly any permanent water courses, except the Juba and Shebelle Rivers, Somalia's numerous dry river beds can rapidly turn into raging rivers, leading to destruction of lives and properties. Flooding of the Juba and Shebelle rivers occurs following heavy and sustained rainfall in the Ethiopian Highlands.

Eritrea has no permanent rivers; all the dry river beds form seasonal streams that come

alive during the rains. Due to the widespread destruction of wetlands for fuel wood and construction purposes, the highlands have been denuded of vegetation. Flash floods therefore are frequent even for the small rainfalls, leading to destruction of property and loss of lives.

2. GENERAL OBSERVATIONS

In most of the IGAD countries, flooding is related to environmental degradation – especially the harvesting of natural resources such as fuel wood. Most of the energy requirements for the local people are met by the unsustainable harvesting of wood – mostly for cooking – but also for buildings. These uses are set to increase with the rapid rise of populations and the lack of viable alternatives to wood.

With the countries that do not have natural permanent rivers, it is not possible to use hydropower; the alternatives to fuel wood are therefore limited to oil and gas, which are not readily available to the locals. However, gleaning from the experiences of the advanced countries, the widespread use of electricity reduced the destruction of forests and allowed afforestation to be done, albeit on a small scale in most cases.

The use of fuel oil for generation of power is being practised in many of the countries on a large scale. This is an expensive method and is therefore not sustainable, especially since the countries themselves are too poor to begin with.

The IGAD countries must therefore address population control with increased energy as this is the most sustainable way to reduce the over-exploitation of the natural resources the countries are endowed with.

ASSESSMENT OF WATER QUALITY AND POLLUTION ON THE SUB-REGIONAL LEVEL

1. INTRODUCTION

It is recognised that pollution prevention is far more effective in reducing pollution than by treating wastewaters. Pollution prevention is the reduction or elimination of contaminants at the source before they have a chance to pollute water resources – and it is almost always the cheapest, easiest, and most effective way to protect water quality. Pollution prevention strategies reduce or eliminate the use of hazardous substances, pollutants, and contaminants; modify equipment and technologies so they generate less waste; and reduce fugitive releases and water consumption. Pollution prevention will also require better design of human settlements to improve water infiltration and reduce nonpoint source pollution. As the world takes on the challenge of improving water quality, pollution prevention should be prioritized in international and local efforts⁷⁵.

Numerous human activities impact water quality, including agriculture, industry, mining, disposal of human waste, population growth, urbanization, and climate change. Most polluted freshwater ends up in the oceans, damaging coastal areas and fisheries.

A good strategy for the prevention of water pollution would have the following benchmarks:

- Clear focus on the prevention of pollution of waters by taking actions to reduce the contamination of water at the polluter's premises and the discharge, without treatment, of contaminated waters.
- Expansion and improvement of water and wastewater treatment systems. Many of the wastewater treatment systems such as in Kenya, where 30% of the urban areas have sewerage systems, are poorly functional, if at all. Rehabilitation and upgrading of the existing systems is therefore important intervention point.
- Restoration, management and protection of ecosystems: Healthy ecosystems provide important water quality functions by filtering and cleaning contaminated water. By protecting and restoring natural ecosystems, broad improvements in water quality and economic well-being can occur. In turn, ecosystem protection and restoration must be considered a basic element of sustainable water quality efforts.

⁷⁵. United Nations Environment Programme, 2010: Clearing the Waters, a Focus of Water Quality Solutions.

Mechanisms for the achievement of the above would involve:

- Improvement of the communities understanding of water quality through improved monitoring - ongoing monitoring and good data are the cornerstones of effective efforts to improve water quality. Addressing water quality challenges will mean building capacity and expertise and deploying real-time, low-cost, rapid, and reliable field sampling tools, technologies, and data-sharing and management institutions.
- Effective communication and education by effectively demonstrating the importance of water quality to households, the media, policy makers, business owners, and farmers can have a tremendous impact in winning key improvements.
- Improved financial and economic tools: better understanding of the economic value of maintaining ecosystem services and water infrastructure is required, as are more effective water-pricing systems that permit sufficient cost recovery, ensure adequate investments, and support sustainable long-term operation and maintenance.
- Effective methods of water treatment and ecosystem restoration and
- Effective application and enforcement of legal and institutional arrangement and political leadership and commitment at all levels: new and improved legal and institutional frameworks to protect water quality are needed from the international level down to the watershed and community level. As a first step, laws on protecting and improving water quality should be adopted and adequately enforced. Model pollution prevention policies should be disseminated more widely, and guidelines should be developed for ecosystem water quality as they are for drinking water quality. Planning at the watershed scale is also needed to identify major sources of pollution and appropriate interventions, especially when watersheds are shared by two or more political entities.

The UNEP recognizes challenges in water:

2. CONTAMINANTS

Many contaminants combine synergistically to cause worse, or different, impacts than the cumulative effects of a single pollutant. Continued inputs of contaminants will ultimately exceed an ecosystem's resilience, leading to dramatic, non-linear changes that may be impossible to reverse. Contaminants include nutrients such as nitrogen and phosphorus from agricultural runoff; human and industrial waste.

2.1. Nutrients

Nutrient enrichment can increase rates of primary productivity (the production of plant matter through photosynthesis) to excessive levels, leading to overgrowth of vascular plants (e.g. water hyacinth), algal blooms, and the depletion of dissolved oxygen in the water column, which can stress or kill aquatic organisms. Some algae (cyanobacteria) can produce toxins that can affect humans, livestock, and wildlife that ingest or are exposed to waters with high levels of algal production. Nutrient enrichment can also cause acidification of freshwater ecosystems, impacting biodiversity. Over the long term, nutrient enrichment

can deplete oxygen levels and eliminate species with higher oxygen requirements, such as many species of fish, affecting the structure and diversity of ecosystems.

2.2. Erosion and sedimentation

Erosion is a natural process that provides sediments and organic matter to water systems. In many regions, human activities have altered natural erosion rates and greatly altered the volume, rate, and timing of sediment entering streams and lakes, affecting physical and chemical processes and species' adaptations to pre-existing sediment regimes. Increased sedimentation can decrease primary productivity, decrease and impair spawning habitat, and harm fish, plants, and benthic (bottom-dwelling) invertebrates. Fine sediments can attract nutrients such as phosphorus and toxic contaminants such as pesticides, altering water chemistry.

2.3. Water temperature

Raised water temperatures caused, for example, by large industrial activities which discharge water into rivers and lakes, can impair reproductive success and growth patterns, leading to long-term population declines in fisheries and other classes of organisms. Warmer water holds less oxygen, impairing metabolic function and reducing fitness. Such impacts can be especially severe downstream of thermal or nuclear power generation facilities or industrial activities, where the return of water to the streams may be substantially warmer than ecosystems are able to absorb.

2.4. Acidification

The pH of different aquatic ecosystems determines the health and biological characteristics of those systems. A range of industrial activities, including especially mining and power production from fossil fuels, can cause localized acidification of freshwater systems. Acid rain, caused predominantly by the interaction of emissions from fossil fuel combustion and atmospheric processes, can affect large regions. Acidification disproportionately affects young organisms, which tend to be less tolerant of low pH. Lower pH can also mobilize metals from natural soils, such as aluminum, leading to additional stresses or fatalities among aquatic species. Acidification is widespread, especially downwind of power plants emitting large quantities of nitrogen and sulfur dioxides, or downstream of mines releasing contaminated groundwater.

2.5. Salinity

Freshwater plant and animal species typically do not tolerate high salinity. Various actions, often but not exclusively anthropogenic, can cause salts to build up in the water. These include agricultural drainage from high-salt soils, groundwater discharge from oil and gas drilling or other pumping operations, various industrial activities, and some municipal water treatment operations. Additionally, the chemical nature of the salts introduced by human activities may differ from those occurring naturally; for example, there may be

higher ratios of potassium than sodium salts. Rising salinity can stress some freshwater organisms, affecting metabolic function and oxygen saturation levels. Rising salinity can also alter riparian and emergent vegetation, affect the characteristics of natural wetlands and marshes, decrease habitat for some aquatic species, and reduce agricultural productivity and crop yields.

2.6. Pathogenic organisms

Pathogenic organisms: bacteria, protozoa, and viruses pose one of the leading global human health hazards. The greatest risk of microbial contamination comes from consuming water contaminated with pathogens from human or animal faeces. A number of pathogenic microorganisms are free-living in certain areas or are, once introduced, capable of colonizing a new environment. These free-living pathogens, like some *Vibrio* bacterial species and a few types of amoebas, can cause major health problems in those exposed, including intestinal infections, amoebic encephalitis, amoebic meningitis, and occasional death.

Viruses and protozoa also pose human health risks, including *Cryptosporidium* and *Giardia*, Guinea worm, and others.

2.7. Trace metals

Trace metals, such as arsenic, zinc, copper, and selenium, are naturally found in many different waters. Some human activities like mining, industry, and agriculture can lead to an increase in the mobilization of these trace metals out of soils or waste products into fresh waters. Even at extremely low concentrations, such additional materials can be toxic to aquatic organisms or can impair reproductive and other functions. In the early 1980s, high concentrations of selenium in agriculture drainage water discharged to the Kesterson National Wildlife Refuge in California extirpated all but one species of fish and caused widespread bird die-offs, as well as severe deformities in several bird species.

2.8. Chemicals and toxins

Other human produced chemicals and toxins include pesticides and industrial processes, and their breakdown products. Dioxins, furans, and polychlorinated biphenyls (PCBs) are the byproduct of industrial processes and enter the environment both through their use and disposal.

For some of these materials, non-lethal doses may be ingested by invertebrates and stored in their tissues, but as larger organisms consume these prey species, the amounts of pesticides and other materials bio-accumulate, eventually to toxic levels. Some pesticides break down in the environment over time, but breakdown products may also be toxic and can concentrate in sediments, to be released in large volumes during scouring events or other disturbances.

2.9. Introduced species and other biological disruptions

There are several incidents of invasive species that have appeared in the waters displacing endemic species and altering water chemistry and local food webs; they pose water quality problems to the environment.

Aquatic species have in many cases been introduced deliberately into distant ecosystems for recreational, economic, or other purposes. In many instances, these introductions have decimated endemic fish and other aquatic organisms, and they can also degrade local watersheds. Other species have invaded inadvertently, transported on the hulls of recreational watercraft or in the bilge water of commercial boat traffic.

For example, invasive species such as zebra (*Dreissena polymorpha*) and quagga (*D. bugensis*) mussels have devastated local ecosystems, altering nutrient cycles and pushing endemic species to the brink of extinction. Mussels in particular also pose grave threats to human infrastructure, clogging pumps and intakes and choking canals, leading to costly and continual maintenance challenges.

Djibouti notes the presence *Prosopis Juliflora* which has invaded Gobaad, Hanlé and Agna districts. *P. juliflora* is considered a noxious invader in the Afar Region of Ethiopia, where it was introduced in the late 1970s and early 1980s. In the Afar region its aggressive growth leads to a monoculture, denying native plants water and sunlight, while denying its nutrients with the animals that eat its pods or its leaves.

Another invasive species is the water hyacinth (the commonest of which is *Eichhornia crassipes*). This has infested large parts of Lake Victoria, the River Nile and its tributaries. The hyacinth has been controlled in Uganda to a large extent but remains a nuisance along the River Nile.

3. SOURCES OF CONTAMINANTS

The main sources of contaminants to both surface and ground waters include (Figure 30) :



FIGURE 30: Chemical products from the on the aquifer at Djibouti

3.1. Agriculture: pesticides

Agricultural activity	Impacts	
	Surface water	Groundwater
Tillage/ploughing	Sediment/turbidity: sediments carry phosphorus and pesticides adsorbed to sediment particles; siltation of river beds and loss of habitat, spawning ground, etc.	Soil compaction can reduce infiltration to the groundwater system
Fertilizing	Runoff of nutrients, especially phosphorus, leading to eutrophication causing taste and odour in public water supply; excess algal growth leading to de-oxygenation of water and fish kills	Leaching of nitrate to groundwater; excessive levels are a threat to public health
Manure spreading	Carried out as a fertilizer activity; spreading on frozen ground results in high levels of contamination of receiving waters by pathogens, metals, phosphorus, and nitrogen leading to eutrophication and potential contamination. In addition, manure application can spread antibiotics and other pharmaceutical products that are given to livestock	Contamination of groundwater, especially by nitrogen
Pesticides	Runoff of pesticides leads to contamination of surface water and biota; dysfunction of ecological system in surface waters by loss of top predators due to growth inhibition and reproductive failure; public health impacts from eating contaminated fish. Pesticides are carried as dust by wind over very long distances and contaminate aquatic systems thousands of miles away (e.g. tropical/subtropical pesticides found in Arctic mammals)	Some pesticides may leach into groundwater causing human health problems from contaminated wells
Feedlots/animal corrals	Contamination of surface water with many pathogens (bacteria, viruses, etc.) leading to chronic public health problems. Also contamination by metals, antibiotics, and other pharmaceuticals contained in urine and faeces	Potential leaching of nitrogen, metals, etc. to groundwater
Irrigation	Runoff of salts leading to salinization of surface waters; runoff of fertilizers and pesticides to surface waters with ecological damage, bioaccumulation in edible fish species, etc. High levels of trace elements such as selenium can occur with serious ecological damage and potential human health impacts	Enrichment of groundwater with salts, nutrients (especially nitrate)
Clear cutting	Erosion of land, leading to high levels of turbidity in rivers, siltation of bottom habitat, etc. Disruption and change of hydrologic regime, often with loss of perennial streams; causes public health problems due to loss of potable water	Disruption of hydrologic regime, often with increased surface runoff and decreased groundwater recharge; affects surface water by decreasing flow in dry periods and concentrating nutrients and contaminants in surface water
Silviculture	Broad range of effects: pesticide runoff and contamination of surface water and fish; erosion and sedimentation problems	Soil compaction limits infiltration
Aquaculture	Release of pesticides and high levels of nutrients to surface water and groundwater through feed and faeces, leading to serious eutrophication	

Quoted from FAO, 2006 in UNEP, *Clearing the Waters, a Focus on Water Quality*, 2010.

TABLE 5. Agricultural impacts on water quality

3.2. Energy production

The production of energy also has significant impacts on water quality (see Table 6 below), mostly because of the vast quantities of water required for power-plant cooling and the extensive risk of contamination during the search for and production of fossil fuels. There are three major impacts of concern: (1) the production of vast quantities of contaminated groundwater during the drilling of oil and gas wells; (2) the withdrawal of water for power plant cooling that reduces water available for ecosystems; and (3) the heating and subsequent discharge of cooling water, which raises the ambient water temperature in rivers, streams, and lakes, with effects on natural ecosystems. Some wastewater is also produced by certain power plants, with concomitant impacts on water quality.

Energy process	Connection to water quality
Energy extraction and production	
Oil and gas exploration	Impact on shallow groundwater quality
Oil and gas production	Produced water can impact surface and groundwater
Coal and uranium mining	Tailings and drainage can impact surface water and groundwater
Electric power generation	
Thermoelectric (fossil, biomass, nuclear)	Thermal and air emissions impact surface waters and ecology
Hydro-electric	Can impact water temperatures, quality, ecology
Solar PV and wind	None during operation, minimal water use for panel and blade washing
Refining and processing	
Traditional oil and gas refining	End-use can impact water quality
Bio-fuels and ethanol	Refinery wastewater treatment
Synfuels and hydrogen	Wastewater treatment
Energy transportation and storage	
Energy pipelines	Wastewater requires treatment
Coal slurry pipelines	Final water is poor quality, requires treatment
Barge transport of energy	Spills or accidents can impact water quality
Oil and gas storage caverns	Slurry disposal impacts water quality and ecology

Quoted from the US Department of Environment in UNEP: *Clearing the Waters, a Focus on Water Quality Issues*, 2010

TABLE 6. Connections between the energy sector and water quality

3.3. Mining

Mining and drilling for fossil fuels bring to the surface materials long buried in the earth, including water. They also tend to generate large quantities of waste materials or by-products relative to the target resource, creating large-scale waste disposal challenges.

Additionally, surface water may drain into mine openings, and groundwater frequently accumulates in mines. Mine drainage waters can be extremely polluted by salts in the groundwater itself; metals such as lead, copper, arsenic, and zinc present in the source rock; sulphur compounds leached from rock; and mercury or other materials used in extraction

and processing.

The pH of these drainage waters can be dramatically altered. Some mine drainage is extremely acidic, with a pH of 2-3; other source materials can lead to very alkaline discharges. These contaminated drainage waters can devastate local waterways, eliminating fish and rendering streams unfit for human use.

3.4. Water-system infrastructure

All human-built systems can lead to the introduction of non-native species; altered water quality (nutrients, oxygen, temperature); changes in system dynamics (flow size, duration, and timing); and the ability of ecosystems to flourish. Water-supply infrastructure, including irrigation systems and dams, affect water quality through a number of mechanisms. These impacts are sometimes classified as follows:

- First order impacts that involve modifying the physical, chemical, and geo-morphological characteristics of a river and stream flow, including altering the natural quantity, distribution, and timing;
- Second order impacts that involve changes in the biological productivity and characteristics of riverine ecosystems and downstream habitats such as wetlands and deltas; and
- Third order impacts that involve alterations to flora or fauna (such as fish, amphibians, or birds) caused by a first-order effect (such as blocking migration or destruction of spawning habitat) or a second-order effect (such as changes in temperature, decrease in the availability of a food source, or mobilization of a contaminant). Third-order impacts can also include effects on human health, industrial or agricultural productivity, or even politics.

3.5. Uncontrolled disposal of human wastes

A major activity that leads to widespread water quality problems is the disposal of human waste. Faecal contamination often results from the discharge of raw sewage into natural waters – a method of sewage disposal common in developing countries.

3.6. Population growth, urbanization, development

Growing populations, especially when concentrated in urban settings, can create more domestic waste and sewage that can overload streams and treatment systems, leading to even more polluted waters.

The high concentration of impervious surfaces increases runoff from roads and carry numerous pollutants such as oils, heavy metals, rubber, and other automobile pollution into waterways and streams. The reduction in water percolation into the ground can also affect the quantity and quality of groundwater. Storm water runoff in urban areas can overwhelm combined storm water and wastewater treatment systems when high volume flows exceed treatment capacities.

3.7. Climate change

Climate change may cause increases in water temperature and changes in the timing and amount of runoff that are likely to produce unfavourable changes in surface water quality, which will in turn affect human and ecosystem health. The threats posed by climate change will serve as an additional stressor to many already degraded systems, particularly those in developing countries.

In regions that will experience increases in precipitation, more runoff will present its own water quality challenges. Pollutants associated with human activity, including pesticides, heavy metals, and organic matter, may flow into surface water faster and with less time for natural water filtration and groundwater infiltration. However, in some regions, this same increase in water flow could potentially dilute these contaminants, improving water quality. Climate change may affect water quality, overloading infrastructure, such as storm water drainage operations, wastewater systems, treatment facilities, mine tailing impoundments, and landfills, which can increase the risk of contamination.

4. WATER QUALITY SOLUTIONS

4.1. Prevention of pollution

Preventing pollution at its source, in industry, agriculture, and human settlements, is often the cheapest, easiest, and most effective way to protect water quality. In an industrial setting, this strategy is commonly called cleaner production, and the need for both government and industry involvement in promoting cleaner production was articulated in Agenda 21 at the United Nations Conference on Environment and Development in 1992, and again ten years later at the World Summit on Sustainable Development.

The elimination or reduction of contaminant use can be accomplished by:

- In industry, reformulating products that produce less pollution and require less resources during their manufacture and use;
- In agriculture, reducing the use of toxic materials for pest control, nutrient application, and water usage;
- In human settlements, reducing the amount of hazardous materials used and disposed and reducing wastewater production;
- Modifying equipment or technologies so that they generate less waste;
- Implementing better training, maintenance, and housekeeping so that leaks and fugitive releases are reduced; and
- Reducing water consumption.

Pollution prevention aims at reducing or stopping the generation of pollution while pollution control aims to manage the end of pipe practices such as waste storage and transport; recycling; energy recovery; waste treatment; waste disposal and waste segregation.

4.2. Protection of water sources

Increasingly, water planners and communities are looking to source water protection as a key to improving water quality and decreasing treatment costs⁷⁶. The traditional approach to water management involves treating water at many stages to remove contaminants. The environmental and economic costs of this strategy are high, particularly as energy costs rise. A new paradigm is emerging, which focuses on protecting the sources of vital drinking water supplies from contamination in order to reduce or eliminate the need for treatment. Healthy, resilient ecosystems help purify and regulate water, thereby avoiding pollution entering into waterways.

4.3. Prevention of industrial point source pollution

Prevention or reduction of industrial point source pollution may be done through adoption of cleaner production techniques; most of the IGAD countries also have cleaner production centres supported by the UNEP. The basic concept behind cleaner production is to increase the efficiency of use of raw materials, energy, and water and reduce sources of waste and emissions.

4.4. Prevention of agricultural non-point pollution

Agricultural activities around the world contribute significantly (about 70 percent on average) to water-pollutant loads. Contaminated agricultural runoff often includes nitrogen, phosphorus, pesticides, and sediment, which impair both surface and groundwater. There are several ways to reduce the impacts of agriculture on water quality, and scales of intervention from the farm level to the state.

Reduction of agricultural pollution can be done at the farm level through reduction of the use of chemical fertilizers with the adoption of crop rotation, mulching, composting and cover cropping and integrated pest management⁷⁷.

At the basin level, the types and locations of different land uses should be considered to control agricultural runoff. Steep slopes facilitate the runoff of water, sediment and chemicals from agricultural lands. Contour farming and terracing can decrease erosion and runoff from agricultural field and are critical for pollution prevention on steep slopes.

At the national or provincial level, governments need to put in place regulations and policies to control and enforce agricultural practices that reduce runoff pollutant levels and ensure that they are able to enforce them through monitoring, measurement, fines or other

⁷⁶ An example of lack of adequate source protection is the issue of the Nakivubo Channel that is polluting Murchison Bay, from which the water treatment plants for Kampala City are based; see Government of Uganda, Final Environment Report prepared for the SSO Project. The treatment costs for the NWSC have risen sharply over the last few years since the pollution broke through the protective swamp of Nakivubo Swamp. Waste that is dumped into the channel from the City now finds itself in the area of abstraction of water for Kampala with little settlement and natural treatment by the swamp. Algal blooms owing to the high nutrient content of the water have been observed.

⁷⁷ Integrated pest management uses particular cultivation practices and beneficial insects to control pests.

consequences for violations. State programs can help farmers to implement innovative practices through technical outreach and assistance. They can also provide financial incentives for adoption of farming techniques that use fewer inputs, and provide grants or loan programs for upgrading infrastructure and installing more efficient irrigation systems.

4.5. Prevention of pollution from human settlements

Traditionally, urban and suburban development has not taken into consideration the effects on natural hydrologic processes. Settlements can reduce aquifer recharge by reducing recharge areas. The many impervious surfaces in cities – streets, roofs, parking lots, sidewalks – prohibit water from infiltrating into the ground and result in large quantities of urban runoff. This runoff collects pollutants as it flows across city surfaces.

The significance of polluted runoff to water quality problems highlights the link between land use and water quality and the need to better integrate water quality concerns into development and land-use planning and policies. These policies and strategies should encourage the use of vegetation and permeable surfaces to allow infiltration of water into the ground, thereby reducing the quantity of potentially polluted runoff and allowing natural filtration through the soil to enhance water quality. Infiltration of the water into the soils in cities and towns rather than it running directly into the side drains and storm sewers can reduce the suspended solids load, organic pollutants and heavy metals by 90% in the storm water. The emphasis for storm water should be infiltrating and/or treatment of storm runoff onsite.

4.6. Treatment of water to remove pollution

If efforts to prevent pollution from entering water sources are ineffective or insufficient, mechanisms to treat the water to improve quality for drinking and other purposes should be undertaken.

Drinking water can be treated for consumption at the municipal level, the community level, or at the household level.

At the municipality / town level, water can be sourced from groundwater, rivers, lakes, canals, reservoirs, and even from seawater. After transporting water from the source, the utility needs to treat this water to ensure that it is suitable to drink by improving the physical, chemical, and biological characteristics of the water. Chlorine or chlorine based disinfectants are used which leave a residual to the tap. Ozone is also used for disinfecting water after treatment.

At the community level, the commonest sources of water are springs, boreholes, shallow wells and rainwater harvesting systems. These sources of water may need to be treated to make the water potable since the groundwater may be polluted.

5. WASTEWATER TREATMENT

Wastewater treatment can be conducted through centralized municipal-level systems (i.e.,

large systems that treat wastewater from many users at one site) or decentralized systems (i.e., those that treat wastewater from individual homes or businesses or small groups of individual users). Centralized systems usually discharge to surface waters, whereas decentralized systems can produce water for local reuse, release to the soil or local surface water, or further treatment as needed. In most developing nations, centralized systems are insufficient, unreliable, or simply absent and the wastewater of many local communities is simply discharged directly into waterways. Over 80% of the wastewater is discharged directly into receiving water courses.

Decentralized systems often provide a cheaper alternative to centralized systems; however, they are more prone to being poorly designed, have less oversight, and can be a major source of groundwater contamination if they do not adequately treat wastewater.

At the municipal level, wastewater consists of liquid carried by human wastes from toilets, washing facilities, kitchens, and other typical household water uses. It also includes commercial wastewater and some from industries. Wastewater quality is compromised physically (e.g., color, odor, temperature, etc.); chemically (e.g., biochemical oxygen demand, total organic carbon, etc.); and biologically (e.g., microbiological contaminants like coliforms, pathogens, viruses). To treat these waters, physical, chemical, and biological processes are used which result in two output streams, one of treated effluent, and the second of solid waste or sludge.

Physical water treatment technologies rely on separating or filtering contaminants from wastewater, or simply destroying those contaminants, using mechanical systems. Filtration is often achieved by running contaminated waters through fine grates or using reverse osmosis systems that separate often very small contaminants from water. The process of letting suspended solids settle at the bottom of a holding area (known as sedimentation) has long been used to allow for easier removal of contaminants. Mechanical means to stir water can be used to promote coagulation, which also makes contaminants easier to remove through subsequent filtering or settling processes. Boiling/incineration and irradiation are also considered physical methods and can disinfect (i.e., remove or neutralize certain pathogens) wastewater.

Chemical water treatment technologies rely on introducing chemicals that break apart, neutralize, or aggregate contaminants. Chemical solutions are able to “clean” small pollutants – such as nutrients like nitrates and phosphates, as well as microorganisms – from wastewaters that are not captured using physical treatment methods. Chemical treatments often use either disinfection or coagulation/flocculation to clean wastewater. Disinfection is the treatment of effluent using chemicals to destroy pathogens.

The most common disinfecting agent used in water treatment has been chlorine; however a variety of chemicals, such as aluminium and iron salts, ozone, and UV-light, can be used. Coagulation and flocculation is the process of destabilizing contaminants to allow them to bind smaller contaminants into larger aggregates to make them easier to separate physically.

Biological solutions rely on the natural processes of living organisms – such as microbes or

plants – to treat wastewater. For example, trickling filters consist of a fixed bed of materials, such as rock, peat moss, or polyurethane foam covered with a film of microbial growth that cleans contaminants through absorption and adsorption. Activated sludge methods use microorganisms to convert carbon found in wastewater into carbon dioxide and water or to adjust nitrogen levels. Wastewater treatment systems are also increasingly incorporating outdoor “constructed wetlands” that use plant systems to break down contaminants before they are released to natural water bodies.

SUB-REGIONAL ENVIRONMENTAL MANAGEMENT PLAN

1. INTRODUCTION

The key environmental issues that have been analysed in the chapters above are:

1. Climate variability/change, drought and desertification.
2. Flooding and erosion risk; sedimentation.
3. Water pollution and quality; solid wastes; pesticides.

2. ANALYSIS OF COPING STRATEGIES AND ACTIONS WITH THE FORMULATION OF SUB REGIONAL COPING STRATEGIES

Coping strategies are strategies prepared by the national governments in order to help mitigate the impacts of the environmental challenges facing their countries at present.

Under the three broad headlines of climate change; water and soil pollution and flooding and land degradation, we have prepared the coping strategies that have been incorporated (in summary) in the Environmental Management Plan (EMP).

3. MITIGATION MEASURES FOR CONTROLLING AND IMPROVING THE KEY ENVIRONMENTAL ISSUES THAT WILL BE BASES FOR SUB-REGIONAL DECISION MAKING

The proposed mitigation measures are given in the EMP Table 7.

4. ENVIRONMENTAL MANAGEMENT PLAN

The sub regional environment management plan is given in the table below.

No.	The Nature of Negative Impact	Potential Impacts	Mitigation Measures and Coping Strategies	Monitoring Indicators	Responsibility
1	<p>Climate change and variability – this is a widespread impact on forestry, agriculture, rangelands, livestock, ecosystems, water resources the economy and the social sectors</p>	<ul style="list-style-type: none"> Droughts, flash floods and other extreme weather patterns/events which lead to destruction of infrastructure and personal property Famines and food insecurity Changed weather patterns Poor water quality; erosion and sedimentation impacts Displacement of people (IDPs) Failure in agriculture, fishery and ecosystems Deforestation and land degradation Desertification Rural-urban migration leading to slum creation Salinisation of groundwater/soils Changes in land tenure systems Social and economic upheaval especially in the ASAL areas Frequent outbreak of diseases such as malaria, dengue fever and waterborne diseases Loss of traditional coping mechanisms Failure of irrigated systems Potential water wars between nations as they scramble for it 	<ul style="list-style-type: none"> Integrated water, land and environment resources management (IWRM) Preparation and updating of climate change adaptation strategies Adoption of alternative livelihoods for the affected peoples such as aquaculture and mixed pastoralism and agriculture Erosion control Reforestation and protection of the existing forests from encroachment Rehabilitation of denuded areas Policy, legal and institutional improvements to focus the government efforts into fighting and mitigation of climate change Countries should join and exploit the international environmental agreements and conventions Capacity building, technical assistance and financial support to governments Carbon offset trading Improved social services especially to the most vulnerable and displaced persons Early warning systems 	<ul style="list-style-type: none"> Policy, legal and institutional frameworks prepared and applied. Monitoring of deforestation, desertification, loss of ecosystem services, agriculture and fishery production, rural-urban migration and poverty measurement and monitoring in place based on national baselines Success of international efforts to address the climate change issues Availability of funding nationally and internationally for climate change actions Success of national and international early warning systems Sensitisation of the local people and mainstreaming of the climate change agenda (IEC) 	<ul style="list-style-type: none"> At the national level, the government is responsible for the overall directions of the climate change activities. Regional bodies such as IGAD, the UN and management of relevant environmental conventions. Local and community leaders

TABLE 7. Environmental Management Plan

No.	The Nature of Negative Impact	Potential Impacts	Mitigation Measures and Coping Strategies	Monitoring Indicators	Responsibility
2	<p>Water and soil pollution from salinisation, water logging, agrochemicals, pesticides, salt water intrusion, garbage dumping, sewage disposal</p>	<ul style="list-style-type: none"> • Salt water intrusion affects the potable water supplies of large areas such as the City of Djibouti, leading to drinking water shortages and increased treatment costs • Pollution from improper collection and disposal of sewage and industrial effluents • Pollution from improper collection and disposal of solid waste; leachate enters water courses • Oil industry wastes – oil and produced water polluting land and water; heavy metals and other toxic substances are usually present in significant quantities • Overloading of existing often poorly managed and old wastewater treatment plants • Acidification of receiving water courses • Increases in water temperature from discharge of warm water in to the rivers • Pollution by heavy / trace metals • Groundwater pollution through pit latrines and septic tanks, esp. in slums and IDP camps • Damage to irrigated lands. 	<ul style="list-style-type: none"> • Reduce the exploitation of the aquifers that do not have adequate recharge through close monitoring and measurements • Freshwater transfers to areas affected by salt water intrusion • Salinisation and pesticide pollution require change in irrigation systems to conserve water and remove nutrients, including treatment of effluents • Water logging of the irrigated areas requires improved technology such as drip/sprinkler irrigation • Concerted rehabilitation of lands that are water logged/saline/polluted with pesticides • Better monitoring and measurement of pollution levels at factories and industrial establishments using the polluter pays principle • Improved policy, legal and institutional framework to enforce regulations and detect and penalise polluters • Construction/rehabilitation of wastewater and water treatment plants 	<ul style="list-style-type: none"> • Numbers of wastewater and water treatment plants constructed/ rehabilitated/ expanded • Number of boreholes rehabilitated that are affected by salt water intrusion • Acreage of irrigation fields that are rehabilitated from water logging and salinity • Acreage under irrigation using environmentally friendly technologies such as drip/sprinkler irrigation • Policies, laws and institutions to address water pollution and discharge of wastewater • Monitoring, evaluation and enforcement of regulations • Regulation of pesticides and agrochemicals improved 	<ul style="list-style-type: none"> • At the national level, the government shall make the necessary policies, laws and institutional frameworks to address these issues • At the municipal and local levels, the authorities must make the necessary byelaws and enforce them • International and national bodies to support the government in funding, technical assistance, capacity building and enforcement, especially where there are complex investigations needed

No.	The Nature of Negative Impact	Potential Impacts	Mitigation Measures and Coping Strategies	Monitoring Indicators	Responsibility
3	<p>Flooding and land degradation is closely related to climate change; however, flooding also occurs when human settlements are found in flood plains and land degradation occurs where humans destroy delicate habitats</p>	<ul style="list-style-type: none"> Flooding causes loss of life, property and infrastructure such as in Djibouti (1994), Uganda (2007) and Sudan (2009) in the recent past Displacement of people affected by floods Erosion of river banks and beds, erosion of land and crops Spread of diseases such as cholera, dysentery, typhoid, malaria, schistosomiasis and dengue fever Floods often lead to sedimentation of excess silt load and changes in the river alignment; this can lead to loss of arable land, conflict Land degradation leads to loss of ecosystem services, desertification, deforestation, loss of vegetation cover and increased soil loss Flooding however has beneficial impacts such as in the Nile flood plains where the Nile brought in much needed loam soil annually (that is now reduced following erection of dams on the Nile) 	<ul style="list-style-type: none"> Formation of emergency response early warning units for flood prone areas Evacuation of people and resettlement away from the flood prone areas Construction of flood defences such as dykes, dams and channels Formulation of policies, legal and institutional frameworks to address flooding and land degradation on a strategic level Terracing of hillsides and reducing the encroachment of steep slopes Alternative fuels to biomass/fuel wood/charcoal such as natural gas/hydropower/solar Enhance the beneficial flood activities such as deposition of silt and loam soils during annual flooding (Sudan) Encourage tree and grass planting, discourage paving of urban areas, esp. at the homestead level 	<ul style="list-style-type: none"> Frequency of floods that are higher than expected, frequency of flash floods Policy, legal and institutional framework in place for emergency response, early warning and IEC Resettlement of flood displaced people alternative areas that are safer Restoration of damaged infrastructure and property Restoration of damaged ecosystems such as mangrove swamps in Djibouti and Kenya that were damaged 	<ul style="list-style-type: none"> At the national level, the government must put in place the policy, legal and institutional framework to address flooding and land degradation At the municipal level, the authority must put in place byelaws and enforce them The international community and regional organisations to support transboundary flood control, planning and management

COOPERATION ON ENVIRONMENT IN THE IGAD SUB REGION

1. INTRODUCTION

1.1. Relevant international cooperation agreements

The IGAD countries have membership of several international environmental agreements and conventions. This section lists some of the agreements and conventions are not listed below; however, where only one or two IGAD sub region countries are members, this Agreement is not listed⁷⁸.

1.2. United nations framework convention on climate change (kyoto protocol)

The objective of the Kyoto Protocol is to further reduce greenhouse gas (GHG) emissions by enhancing the national programs of developed countries aimed at this goal and by establishing percentage reduction targets for the developed countries.

IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. The Convention entered into force on 23 February 2005. Only Somalia is not a member.

1.3. Montreal protocol on substances that deplete the ozone layer

The objective of the Montreal Protocol is to protect the ozone layer by controlling emissions of substances that deplete it.

IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. The Convention entered into force on 1 January 1989. Only Somalia is not a member.

1.4. Convention on wetlands of international importance especially as waterfowl habitat (ramsar)

The objective of the Ramsar Convention on Wetlands are to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value.

⁷⁸. The main source of the information is the CIA Portal at <https://www.cia.gov/library/publications/the-world-factbook/appendix/appendix-c.html#C>.

IGAD sub region Parties are Djibouti, Kenya, Sudan and Uganda. The Convention entered into force on 21 December 1975. Eritrea, Ethiopia and Somalia are not members.

1.5. Convention on international trade in endangered species (cites)

The objective of CITES is to protect certain endangered species from overexploitation by means of a system of import/export permits.

The IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda. The Convention entered into force on 1 July 1975.

1.6. Basel convention on the control of transboundary movements of hazardous wastes and their disposal

The objectives of the Hazardous Wastes Convention is to reduce transboundary movements of wastes subject to the Convention to a minimum consistent with the environmentally sound and efficient management of such wastes; to minimize the amount and toxicity of wastes generated and ensure their environmentally sound management as closely as possible to the source of generation; and to assist LDCs in environmentally sound management of the hazardous and other wastes they generate

IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. The Convention entered into force on 5 May 1992. Only Somalia is not a member.

1.7. Convention on biological diversity (cbd)

The objective of the CBD is to develop national strategies for the conservation and sustainable use of biological diversity. It entered into force on 29 December 1993.

IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. Only Somalia is not a member.

1.8. United nations convention on the law of the sea (los)

The objective of the Law of the Sea is to set up a comprehensive new legal regime for the sea and oceans; to include rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment.

IGAD sub region Parties are Djibouti, Kenya, Somalia, Sudan and Uganda. Eritrea and Ethiopia are not members. The Convention came into force on 16 November 1994.

1.9. United nations convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in africa

the objective of the UN Convention on Drought and Desertification is to combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements.

It entered into force on 26 December 1996 and the IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda.

1.10. United nations framework convention on climate change

The objective on the Convention on Climate Change is to achieve stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system.

The Convention came into force on 21 March 1994. IGAD sub region Parties are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. Only Somalia is not a member.

1.11. International plant protection convention⁷⁹

IPPC — the International Plant Protection Convention — is an international treaty that aims to secure coordinated, effective action to prevent and to control the introduction and spread of pests of plants and plant products.

The Convention extends beyond the protection of cultivated plants to the protection of natural flora and plant products. It takes into consideration both direct and indirect damage by pests, so it includes weeds. It also covers vehicles, aircraft and vessels, containers, storage places, soil and other objects or material that can harbour or spread pests.

The Convention provides a framework and a forum for international cooperation, harmonization and technical exchange between contracting parties.

Its implementation involves collaboration by National Plant Protection Organizations (NPPOs) — the official services established by governments to discharge the functions specified by the IPPC — and Regional Plant Protection Organizations (RPPOs), which can act as coordinating bodies at a regional level to achieve the objectives of the IPPC.

The convention has been deposited with the Director-General of the Food and Agriculture Organization of the United Nations (FAO) since its adoption in 1951.

The IPPC is an international treaty that applies to most nations involved with international trade in any commodity that could introduce a new plant pest into a new area; in other words, it is applicable to all transboundary movements of plants and plant products.

It is in the interest of all nations to be contracting parties to the Convention: membership means they can play an active part in developing international standards that help to protect their exported and imported goods.

Exchanging technical and official phytosanitary information is vital to the Convention's effective implementation.

IGAD members are Djibouti, Eritrea, Ethiopia, Kenya, Sudan and Uganda. Only Somalia is not a member.

⁷⁹. The website for the IPPC is found at https://www.ippc.int/index.php?id=2&no_cache=1&L=0 from which the Convention was downloaded.

1.12. Convention on the law of the non-navigational uses of international WATERCOURSES

The Convention on the Law of Non-Navigational Uses of International Watercourses is a document adopted by the United Nations on May 21, 1997 pertaining to the uses and conservation of all waters that cross international boundaries, including both surface and groundwater. Mindful of increasing demands for water and the impact of human behaviour, the UN drafted the document to help conserve and manage water resources for present and future generations. To enter force, the document required ratification by 35 countries, but as of 2008 received less than half that number, with ratification by 16. Though un-ratified, the document is regarded as an important step towards arriving at the international law governing water.

2. EAST AFRICAN SUB REGION COOPERATION AGREEMENTS

2.1. Overall cooperation agreements

The East African Community (EAC) is the regional intergovernmental organization of the Republics of Kenya, Uganda, the United Republic of Tanzania, Republic of Rwanda and Republic of Burundi with its headquarters in Arusha, Tanzania.

The Treaty for Establishment of the East African Community was signed on 30 November 1999 and entered into force on 7 July 2000 following its ratification by the original three Partner States – Kenya, Uganda and Tanzania. The Republic of Rwanda and the Republic of Burundi acceded to the EAC Treaty on 18 June 2007 and became full Members of the Community with effect from 1 July 2007.

The areas of cooperation between the five countries include (for which Protocols and Tripartite Instruments have been signed⁸⁰):

- Protocol on Combating Drug Trafficking in the East African Region.
- Tripartite Agreement on Road Transport.
- Tripartite Agreement on Inland Waterway Transport.
- Protocol on the Sustainable Development of Lake Victoria Basin.
- Protocol on Environment and Natural Resources.
- Protocol on the Establishment of the East African Civil Aviation Safety and Security Oversight Agency.
- Protocol on the Establishment of the East African Health Research Commission.
- Protocol on Combating Drug Trafficking in the East African Region
- Tripartite Agreement on Road Transport
- Tripartite Agreement on Inland Waterway Transport

⁸⁰. This selection is only for the environmental related and transboundary protocols and tripartite instruments, up to 2008.

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- Protocol on the Sustainable Development of Lake Victoria Basin

2.2. Protocol on environment and natural resources

The key objectives of the Protocol are geared to ensuring the cooperation in sustainable management and utilisation of natural resources, including transboundary resources, and in harmonising the development of policies and strategies for sustainable development. The areas covered in the Protocol are:

- Management of Transboundary Resources.
- Management of Biological Diversity.
- Management of Forest and Tree Resources.
- Management of Wildlife Resources.
- Management of Water Resources.
- Sustainable Management and Wise Use of Wetland Resources.
- Management of Coastal and Marine Resources.
- Management of Genetic Resources.
- Management of Mineral Resources.
- Management of Energy Resources.
- Management of Mountain Ecosystems.
- Soil and Land Use Management.
- Management of Rangelands.
- Combating Desertification and Mitigating Effects of Drought.
- Protection of the Ozone Layer.
- Tourism Development.
- Management of Chemicals.
- Management of Wastes and Hazardous Wastes.
- Pollution Control and Management.
- Environmental Impact Assessment and Audits.
- Environmental Standards.
- Military and Hostile Activities.
- Public Participation, Access to Justice and Information.
- Environmental Disaster Preparedness and Management.

The Protocol also covers the institutional arrangements for its implementation and monitoring, dispute resolution and related issues.

The Protocol defines arid, semiarid and dry sub-humid areas as those areas in which the ratio of annual precipitation to potential evapotranspiration falls within the range of 0.05 to 0.65. It also defines desertification as land degradation in arid, semiarid and dry sub-humid

areas resulting from various factors, including climatic variations and human activities.

It is a comprehensive environmental cooperation protocol that applies throughout the region, including Kenya and Uganda, which are also members of IGAD.

Key principles recognised in the Protocol include:

- The principle of prior informed consent.
- The principle of notification in cases of activities with transboundary impacts.
- The polluter pays principle.
- The precautionary principle.
- The principle of the unity and coherence of shared ecosystems.
- The principle of subsidiarity in the management of the environmental and natural resources.

CONCLUSIONS AND RECOMMENDATIONS

The key conclusions from the Environmental Component are:

1. Drought, desertification and land degradation are serious threats to nation states in all the IGAD countries. Although these impacts are caused by the global effect of climate change, there are many activities that the individual countries can do individually and collectively to combat these threats. The main vehicle for collective action is IGAD and the international environment conventions to which most of the countries are signatory to.

The countries must therefore join the environmental conventions which are beneficial to them under the IGAD umbrella.

2. Coping with drought, desertification and land degradation is critical to the survival of the nomads and pastoralists of the region; they are the most affected of the communities since their options for survival are limited.

The pastoralists and nomads are the most vulnerable people and urgent actions should be carried out to enable them cope with the severe impacts of climate change.

3. Water dependent agriculture is important in the region; however the potential for irrigation needs to be exploited to create more opportunities for efficiency of water use. However, the lessons from the failed and inefficient irrigation schemes in the region should be taken up by the regional and national bodies so that the known problems can be avoided in the design of the new schemes.

Irrigation should be adopted in the IGAD region but IGAD should coordinate studies to ensure that the lessons learned from the failed or inefficient irrigation schemes in the region are not repeated.

4. Wetlands occur along the coastal areas of Kenya, Somalia, Eritrea and Sudan and also inland in Kenya, Uganda and Ethiopia. Conservation of these wetlands is critical for the environment since they provide environmental services and are refuges for many endangered species. Encroachment and degradation of wetlands needs to be addressed nationally and in a transboundary manner to ensure that actions are acceptable to all the transboundary states. International agreements such as the Ramsar Convention provide a platform for concerted conservation actions.

Protection of wetlands should be a major focus of IGAD since these wetlands are refuges for endangered species and are unable to provide services if they are not sustainably managed. All the countries should join the Ramsar Convention and ensure that they get

the available technical support from the organisation.

- 5.** The IGAD countries have all prepared national action plans to combat environmental impacts; funding of these NAPAs is to be provided through international bodies such as the UNCCD. However, national efforts are critical in planning and implementing the projects that are approved. These require national capacity to carry out the interventions as well as improved policy, legal and institutional frameworks.

IGAD should coordinate the financial and technical support to the countries from UNCCD and other international bodies. Where there are transboundary environmentally sensitive areas, IGAD should be more involved to increase cooperation and build synergies.

- 6.** Water and environmental pollution is a significant problem in all the countries. Significant actions are required in order to contain pollution from urban centres: most of the large towns do not have centralised sewerage systems and rely on on-site methods such as septic tanks and pit latrines which pollute the environment, especially the groundwater. However, sewerage systems are costly to construct and also to maintain. Most of the even the existing ones are now failing. There is a significant issue of pollution from the exploration and exploitation of oil in some of the countries. This is still a growing sector, but its impacts can be large and widespread.

There should be concerted actions to improve on the sewerage and sanitation systems in the urban centres in IGAD countries. The pollution problem from oil exploration and exploitation should be handled at an early stage since more of the IGAD countries are starting to exploit oil reserves.



LITERATURE SOURCES

The IGAD Livestock information portal at http://www.igad-data.org/index.php?option=com_content&view=frontpage&Itemid=1.

The United Nations Environment Programme (UNEP) website at <http://www.unep.org/>.

The United Nations Framework on Climate Change on <http://unfccc.int/2860.php>. The Kyoto Protocol (1998) was obtained from the same website at <http://unfccc.int/resource/docs/convkp/kpeng.pdf> while the Accounting Manual for Emissions was obtained at http://unfccc.int/resource/docs/publications/08_unfccc_kp_ref_manual.pdf.

The Ramsar Convention on Wetlands was available at http://www.ramsar.org/cda/en/ramsar-home/main/ramsar/1^7715_4000_0__ from where their library documents have been downloaded.

The Sahara and Sahel Observatory Project at <http://www.oss-online.org/>.

UNDP in Sudan at http://www.sd.undp.org/focus_environment.htm.

The United States of America Central Intelligence Agency (CIA) Fact Book at <https://www.cia.gov/library/publications/the-world-factbook/>.

The United Nations Convention to Combat Desertification at <http://www.unccd.int/main.php>.

The Food and Agriculture (FAO) website (Africover) at <http://www.africover.org/>.

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation at <http://www.wssinfo.org/resources/documents.html>.

UNDP in Uganda at <http://www.undp.or.ug/>.

The United Nations Statistics Division Millennium Development Goals website at <http://mdgs.un.org/unsd/mdg/Default.aspx>.

The Convention on Migratory Species website found at http://www.cms.int/publications/pdf/CMS_CimateChange.pdf.

Convention on International Trade in Endangered Species (CITES) is found at <http://www.cites.org/> from where some useful documents have been downloaded.

United Nations Convention on the Law of the Sea found at <http://www.un.org/Depts/>

los/convention_agreements/convention_overview_convention.htm. A follow up on this Convention is the Agreement on Migratory Fish stocks found at <http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N95/274/67/PDF/N9527467.pdf?OpenElement>.

The Millennium Assessment documents found at <http://www.millenniumassessment.org/en/Framework.aspx>.

The national environment management agencies and related sites of the individual countries of:

■ Djibouti: there seems not to be a government portal, but the following websites proved useful:

- University of Colorado at Boulder information portal found at <http://ucblibraries.colorado.edu/govpubs/for/djibouti.htm>.
- IGAD Livestock Information portal found at http://www.igad-data.org/index.php?option=com_docman&task=cat_view&gid=69&Itemid=46.
- <http://www.igad-lpi.org/> was also useful.

■ Ethiopia: useful websites include:

- The Ethiopian Environmental Protection Authority found at <http://www.epa.gov.et/epa/home.asp>.
- The UNESCO website for the PASDEP http://planipolis.iiep.unesco.org/upload/Ethiopia/Ethiopia_PRSP_progress_2005.pdf.

■ Kenya: the National Environment Management Authority found at <http://www.nema.go.ke/>.

■ Sudan: the Higher Council for Environment and Natural Resources found at <http://www.hcenr.org/>.

■ Uganda: the National Environment Management Authority found at <http://www.nemaug.org/>. The Ministry of Water and Environment and other ministry websites also proved to be useful.

Mapping, Assessment & Management of Transboundary Water Resources in the IGAD Sub-Region Project



ENVIRONMENTAL COMPONENT

The report is built out of three key environmental thematic areas: drought and desertification; flooding and erosion risk; water quality and pollution. These three areas were covered at national and sub-regional levels, meaning that the volume contains analysis of each of the 7 IGAD Member States and a general sub-regional analysis for each thematic area.

Large areas of the IGAD sub region are arid, semi-arid or desert with more than 50% of their land mass regarded as arid or semi-arid in some of the countries. The impacts of climate change and variability are therefore felt directly by these countries, especially the most vulnerable rural populations. The arid and semi-arid lands are mainly inhabited by the itinerant pastoralists and nomads, some of who combine pastoralism with agriculture. However their habitats are being denuded of vegetation – especially the forests – leading to wider environmental impacts such as land degradation, reduction in ground and surface water resources, pollution of the soils and waters, increased soil erosion and failure by the ecosystems to perform their roles in a sustainable manner.

The rapid population growth and poor socioeconomic structures in these countries make the future bleak for the vulnerable populations. The severity of flooding has increased in all the IGAD countries over the last few decades as a result of climate change and variability which makes rainfall become highly unpredictable.

The IGAD region is experiencing a surge in oil discoveries and will face the problems of increased pollution from exploration and exploitation of oil from the countries. Sudan is already experiencing severe problems with produced water during the exploitation of oil while Uganda is soon moving to the stage of producing oil in the Albertine Graben of Western Uganda.

An important footnote to this report is the fact of the independence of South Sudan from the Sudan which took place on 9 July 2011. This Report gives information that is valid for the combined State of Sudan. There was no opportunity to disaggregate the data to the two separate independent countries at the time of finalising this Report □

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