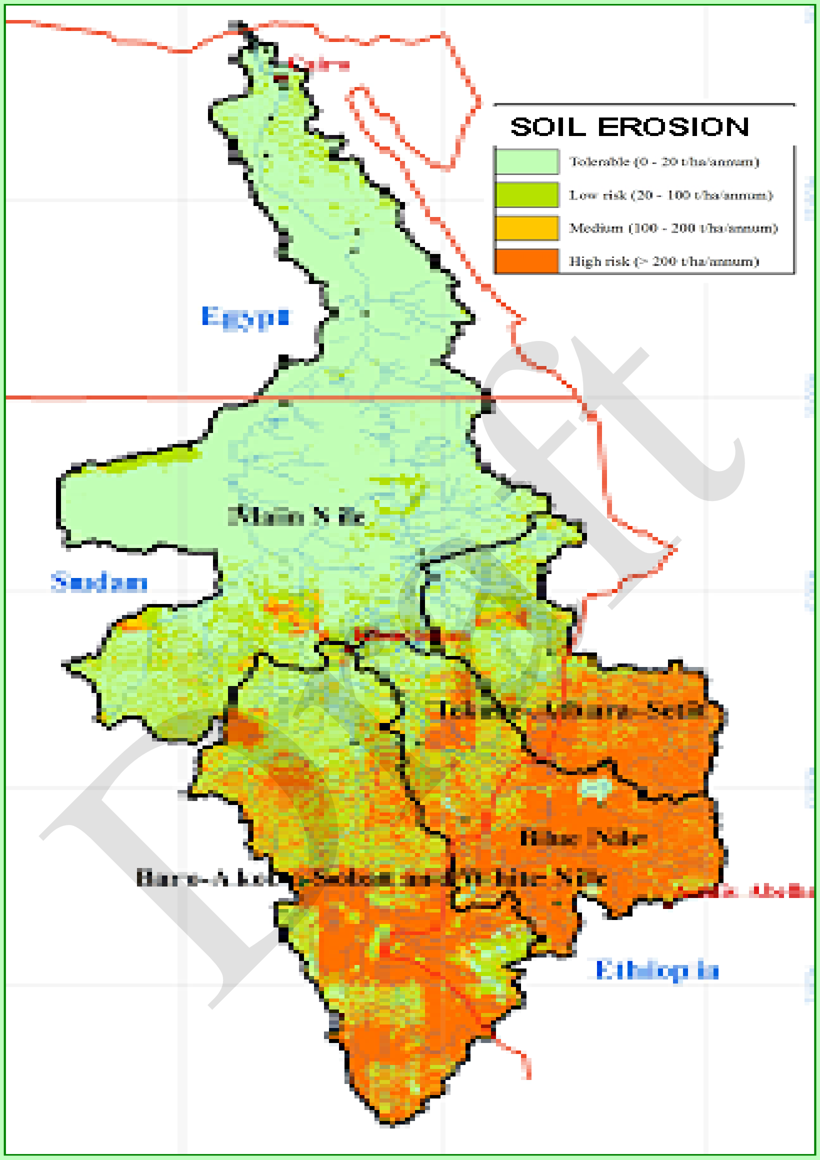
**EASTERN NILE TECHNICAL REGIONAL OFFICE (ENTRO)**

*Synthesis of*

# Environmental Assessment of Eastern Nile Sub Basins

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***Preface***

*This synthesis report deals with the environmental aspect and water quality issues of Baro-Sobat-White Nile, Abbay-Blue Nile, Tekeze-Atbara; and Main Nile sub basins and provides the "No Borders" overview of the Eastern Nile basin in the riparian countries of Ethiopia, Sudan and Egypt. The main purpose of the report is to compile essential baseline information on environment that will be used to support analysis for the identification of multipurpose development programs and projects benefiting the three countries.*

*In its entirety, the work consists of:*

- *The report itself;*
- *Other studies and reports on natural resources and environmental issues;*
- *Policies and legislations related to environmental theme and water quality issues;*
- *Spatial environmental data in semi-processed and structured state; and*
- *Statistical data computed based on known attributes.*

*The report is structured in such a way that the general environmental situations in the sub basins are discussed; available policies, legislations, institutional frameworks and international agreements are assessed in light of the general environmental situations; the current environmental threats are disclosed somehow; the likely impacts of major development programs are explained; and finally, the prevailing institutional constraints, data/information gaps and general recommendations are provided towards formulating the Joint Multi Purpose Programs in the Eastern Nile basin.*

*Accordingly, the report contains seven main parts. The first and second parts provide background and executive summary, respectively. Despite the complete absence of spatial data from the Sudan and Egypt portions of the Eastern Nile basin, the maps the consultant had thought necessary have accompanied the executive summary, while sub basin aggregates have accordingly been annexed. In particular, the background explains the structural inconsistencies and shortfalls encountered in the initial documents of the one system inventory, as prepared by three different consultants in Ethiopia, Sudan and Egypt.*

*The third part extensively assesses the environments of the Eastern Nile basin based primarily on the data and information gathered during the one system inventory assignments. Owing to the emphasis given to water quality issues during the initial compilation, the environmental assessment of the Main Nile in Egypt has been limited in scope as compared to that of the other sub basins.*

*The fourth part of the synthesis emphasizes on environmental policies, legislations, institutional frameworks and international agreements as provided in the initial documents. In the upper part of Baro-Sobat-White Nile, Abbay-Blue Nile and Tekeze-Atbara sub basins in Ethiopia, an independent environmental institution with an authoritative power on all environmental protection issues has been in place while such responsibilities are embodied in different institutions for the lower portion of the abovementioned sub basins in Sudan and the Main Nile in Egypt.*

*The status and threats of the environments in the sub basins have been dealt with in part five, commonly considering land degradation and soil erosion, deforestation and loss of biodiversity, population pressures, climatic variability, loss of wetlands, desertification and environmental pollutions prevalent in respective sub basins.*

*The likely impacts of major development opportunities are covered under the sixth part; while part seven provides core information on the institutional constrains, the gaps observed in data and data qualities; and recommendations pertaining to filling the gaps and conducting further studies in the entire basin. .*

# *1. BACKGROUND*

## *1.1 Background of the Synthesis Report*

### *1.1.1 Proposed Contents of Initial Compilation*

*Around November 2005, consultancy service contracts were signed between the Eastern Nile Regional Technical Office (ENTRO) and the consultants selected to compile basic data and information on the Eastern Nile sub-basins in Ethiopia, Sudan and Egypt. The contract documents, among other things, consisted of the Terms of Reference on the compilation of the data and information deliverables required of each consultant. The work of launching One System Inventory (OSI) was seen as an integral part of the Joint Multipurpose Program (JMP) of the eastern Nile Basin in the riparian countries of Ethiopia, Sudan and Egypt.*

*At the outset, ENTRO provided standard terms of reference for the consultants in the three countries with the view to compiling and developing baseline reports on the environmental issues of those geographies. The broad content of the OSI, as initially provided by ENTRO, was as follow:*

a. *Environmental Regulatory and Institutional Setting;*
    - *Overview of Relevant Policy/Legislative Framework and Programs;*
    - *Rapid Institutional Assessment; and*
    - *Status of Environmental Knowledge base.*
b. *Environmental Baseline by Basin:*
    - *Climate;*
    - *Natural Resource Base Setting by Basin;*
    - *Pollution Status;*
    - *Wastewater Generation Estimate;*
    - *Water Logging, Salinity/Sodicity;*
    - *Waterborne Diseases;*
    - *Use of Agro Chemicals;*
    - *Dam Safety;*
    - *Biodiversity Related to Water; and*
    - *Special Water Related Environmental Issue.*
c. *Impacts of Possible Major Development Opportunities on the Eastern Nile:*
    - *Broad Environmental Perspectives;*
    - *Collation of Existing Information on the Range of Environmental Impacts; and*
    - *Key Points to be considered in Developing JMP.*
d. *Maps:*
    - *Land Use and Land Cover;*
    - *Soils;*
    - *Geomorphology; and*
    - *Climate.*
e. *Comments on the Data Quality and Key knowledge Gaps;*
f. *Conclusion and Recommendations for Further Work; and*
g. *Inclusion of List of References.*

*Accordingly, the deliverables expected of the consultants on the Environment Theme were listed as:*

a. *Compilation of Required Data and Information on Environmental and Related Issues;*
b. *Concise Report with Specific Emphasis on Data Quality and its Interpretation;*
c. *Hardcopies of Key documents Referred;*
d. *List of Annotated References; and*
e. *Softcopy deliverables in English of common Office software (e.g. MS Word, MS Excel, MS Access, Common GIS Software, etc.).*

*However, on the Inception Meeting organized by ENTRO during 1-2 November 2005, a general consensus was reached on the modified version of the OSI outlines due to be used immediately by the Environmental Theme Consultants in the three countries. The modified version of the report outlines could be put broadly as follow:*

a. *Executive Summary;*
b. *Introduction/Background;*
c. *Policy, Institutional Framework and Legislation;*

d. Natural Resources Assessment of the Basin;
e. Past and On-going Environmental Related Activities, Projects and Programs;
f. Environmental Threats;
g. Environmentally Sensitive areas;
h. Likely Impacts of Possible Major Developments (in view of JMP);
i. Critical Information Gaps and Study Needs;
j. Conclusions; and
k. Annexes (stated in the initial TORs).

#### 1.1.2 Structural Problems of Synthesis Report

As has been indicated above, there have been some structural changes made to the contents of the environmental data and information compilation expected from the three consultants. Obviously, the rationale of the needs arose from ENTRO and the consensus accordingly built during the Inception Meeting, rested upon the concept and objective of OSI, which in itself would have acceptable compatibilities and flexible integrity among the data and information at the eventual stage of preparing the synthesis of those reports into a single document, apparently to be placed in the service of identifying and developing relevant development projects under the JMP.

In spite of the consensus built during the Inception Meeting, the OSI reports submitted to ENTRO from the consultants of the three countries significantly lacked compatibilities in terms of content and structural arrangements. Despite the likely importance of some structures and their accompanying contents for ENTRO, there have been serious constraints posed on the preparation of concise synthesis as per the expectation of ENTRO and potential readers of this Synthesis Report. In the personal judgment of the consultant, the report on the sub-basins of Tekeze, Blue Nile (Abbay) and Baro-Akobo went almost according to ENTRO's terms of reference and the contents agreed upon during the Inception Meeting; while compilation on the Atbara, Main Nile in Sudan, Sobat, White Nile and Blue Nile in same were not disappointing in respect of structure. In view of the general need, the case of the report compiled on the lower part of the Main Nile has been the worst scenario due mainly to its entire focus on the Water Quality in that part of Nile Basin. Even though, the major part of the report treated the national issues rather than Basin-specific situations.

In this connection, the present consultant is convinced to highlight to ENTRO and the readers of this synthesis report that it has been due to the entire dwelling of the report on the lower part of Eastern Nile on the Water Quality that the Quality context was included into the main title of the synthesis report, too. The data and information compiled on that part of Nile basin almost entirely emphasized on the fifth part of the OSI's revised outline.

On the other side, the structure of the report on Atbara, Main Nile, Sobat, White Nile and Blue Nile did not consider the revisions made during the inception meeting to the initial version of the assignment. On the other hand, the administrative boundary overlaps of the sub-basins within the countries and around their common boarders challenged contextual referencing to the known sub-basins in the three riparian states. With the exception of the sub-basins in Ethiopia, there had been no spatial data provided in standard GIS software, as stipulated in the terms of reference. It seemed that the consultants were either unwilling or did not consider releasing spatial data in a standard GIS format, and solely annexed fixed images of the GIS maps they produced while preparing the reports.

The gaps remained untouched for Atbara, Main Nile, Sobat, White Nile and Blue Nile sub-basins in the areas such as the Baseline Environmental Status and Impacts of Major Development Opportunities have created a drawback on the completeness of the synthesis, which could have otherwise been invaluable input for the JMP.

Furthermore, in the water quality assessment of the lower main Nile Basin, numerously abbreviated terms had not been annotated therein, hence limiting the textual integration and incorporation as important environmental elements of the synthesis report.

The problems of incompatibility among the initial OSI reports could be attributed, either or wholly, to the following factors:

*a. Absence of timely follow-up by ENTRO;*
*b. Consultants' inadequate emphasis on the terms of reference;*
*c. Absence of relevant data to enrich the reports; and*
*d. Difference in the nature and realities of the physical environments in respective countries;*

*Likewise, the consultant on the synthesis report encountered significant differences of the national environmental regulatory policies, in which almost all available policies, legislations and regulations pertain to national issues thus lacking basin specificity. Some are at the draft stages while others particular only to a given country. In order to have a better impression of the regulatory issues of the environments everywhere, the consultant summarized those issues by amalgamating the sub basins with the exception of the Main Nile in Egypt.*

*The present consultant would, therefore, like to mention that the structural problems and incompleteness in some core environmental issues in this synthesis report should not be attributed to him but to the constraints already inherent in the initial reports of the OSI.*

# 2. EXECUTIVE SUMMARY
## 2.1 ENVIRONMENTAL ASSESSMENT OF EASTERN NILE BASIN

### 2.1.1 General Consideration
The net area of the Eastern Nile basin reaches 1, 787,624 $km^2$, of which the main Nile alone covers about 45 percent. For the rest of the basin, the share of area coverage goes in the order of Baro-Akobo-Sobat and White Nile (26.3 percent), Blue Nile 17.2 percent) and Tekeze-Atbara-Setit (12.9 percent).

About 46 percent of the Eastern Nile basin falls in the altitude range of 200-500 m.a.s.l., which could be considered as desert. Desert and low desert covers close to 50 percent while the mid altitude belonging to the range of 1500 – 2300 m.a.s.l. takes 13 percent of the whole basin. The highland in the upper part of the eastern basin constitutes only 5 percent of the total area.

Analysis of the physiography data ravelled that about 84 percent of the land area in the whole basin belongs to a slope gradient below 5 percent, thus denoting very flat-to-flat relief. The largest part of the flat topography lies in the middle and lower part of the basin. This portion is characterized by floods and sediments caused by the uplands constituting only 10 percent of the whole basin area.

According to data from the FAO and the Woody Biomass Inventory and Strategic Planning Project (Ethiopia), 35 percent of the basin's area is covered by tree crops, followed by croplands, and deciduous woodlands, covering 14 percent and 12 percent, respectively. Grassland occupies close to 11 percent, while forestland coverage is estimated below 2.5 percent of the total area (for *more details, see annex one and two of the main report).*

It is also estimated that about 63 percent of the basin's area receives a mean annual rainfall below 600 mm. Areas belonging to the humid and peri-humid zone in the Upper part, covering 25 percent of the eastern basin area, gets over 900 mm a year. This has resulted in the fact that around 60 percent of the basin gets a mean temperature over 25 $^0$C in the middle and lower regions of the basin.

Poor land cover, high rainfall and irregular topography in the upper part of the basin are believed to cause sever soil erosion hazards over 38 percent of the basin's area. The upper part is a typical zone where much of the hazard occurs, especially during the rainy seasons.

### 2.1.2 Specific Considerations
#### 2.1.2.1 Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile
In those three sub-basins, large areas of forestland have been altered by some form of clearing or tree removal. Many of these areas are occupied for human settlement and agricultural use. Some disturbed forests remain in few areas as National Priority Forest. Nonetheless, their situation has become critical due to exploitation and the uncontrolled burning exceeding the rate of forest growth. Only few primary forests remain occurring on steep lands..

With the high rate of increase in both human and animal populations, remnant woodlands and bush lands continue to be under pressure. A number of factors have contributed to this, including population growth which induces increased demand for agricultural land and pasture; causing increased fuel wood harvesting exceeding both the woodland and bush lands regenerative capacity, long droughts, flooding and high winds. Seedlings, whether from natural regeneration or plantation, usually suffer abrasive dust, sand storms, drought, browsing and animal trampling. As a result, most of the vegetation in the sub basins has disappeared and only little of the original is evident

Among the numerous wildlife, the Walia Ibex, "*Key Kebero" (Ethiopian wolf)* and the Gelada Baboon and the Mountain Nyala, are the major ones in parts of Blue Nile. However, due to the pressure they are encountering, the population has been constantly decreasing.

In the vast plains of the lower altitudes**,** trees and shrubs are usually gathered for domestic animals. Most of the vast plains have been deforested for rain-fed mechanized agriculture, which led to rapid disappearance of the natural vegetation. Over grazing, especially during the rainy season, has become the main hazard to plant density. More than half of the areas in the plains are drought-prone as they lie in the semi-desert belt. The other threat is the hazard of fires. Expansion in mechanized rain-fed agriculture for food production has been at the expense of the natural ranges; and the balance between the numbers of livestock and grazing has been disrupted. There has been illicit felling of trees for domestic and commercial purposes especially in the remote and inaccessible parts of the plains. Lack of clear land use policy has also been an additional constraint to forest conservation. Furthermore, war conditions have led to the destruction of plantations owing to unauthorized felling of trees for commercial logs. Official figures on government plantations in the lower altitude, for instance, illustrate that 80 percent of the teak plantation has been damaged.

In general, there has been severe reduction in wildlife habitats and due to the conversion of large areas of land for agricultural use. This has particularly affected the more densely populated and human favoured higher and cooler altitudes parts of the upper areas, where few large animal habitats remain intact. Changes to the habitat have also occurred due to the introduction of state farms and few dams**.**

In the upper part of Blue Nile, there are limited fish reserves in both lake and riverine systems. Lake Tana has the most important fish resource. Fishing is carried out on a subsistence basis and limited commercial purposes both in the main river channels and many of the floodplain lakes. Virtually, every family that lives near water fishes to supplement its diet. Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus), Catsish (Clarias sp), Bargrus, Barbus and Labeo species are known to be important both in ecological and commercial terms.

However, there is little information on fish species and no systematic fish identification has been done. Neither the number of fishery operations nor evaluation of their catch is available. The fisheries department has not yet collected such information.

With regard to water quality, apart from high sediment loads, the water quality of all rivers that are distant from urban centres appears to be adequate for most uses. Lake Tana with a surface area of 3,042 $km^2$ is the largest freshwater inland lake and remains an important regulating feature in the upper part of Blue Nile. The lake's water quality seems to be satisfactory and is used as a minor source of supply for the town of Bahir Dar.

As to the wetlands, there are areas, which are either permanent swamps such as the Dabus swamp or seasonally receding as around Lake Tana. The main wetland areas within the sub basins occur around Lake Tana, the Finchaa, Chomen swamps, and the large Dabus swamp.

Regarding water related resources with construction of dams, the sub-basin may have a potential for irrigation, drinking water supply and hydropower generation. The hydropower potential of the Tekeze River in the upper part of Tekeze-Atbara-Setit sbu-basin is quite large, rivers are quite steep and some have deep gorges, potentially making ideal dam sites.

It is known that White Nile and Blue Nile meet in Khartum having their tributaries from the plateaus of the upper part and the regions of the Great Lakes. The sources are humid, with an average rainfall of over 1000 mm per year. Converge in Khartoum, the White and Blue Niles and flow north to the Mediterranean Sea. The two tributaries have dramatically different flow patterns. The White Nile's flow is tempered by the natural perennial storage of the Great Lakes, of which Lake Victoria is the most important. Consequently, it is characterized by a relatively steady flow pattern. The annual water input from the equatorial region can reach 400 billion cubic meters, where about 85 percent of the Nile's waters originate in upper parts of Ethiopia and Eritrea.

Dinder National Park with its area of about 890,000 hectares preserves natural wildlife migration corridor. The park is the last remaining wildlife sanctuary in the clay plains. It supports a population of Tiang, Reedbuck, waterbuck, bushbuck, Pribi, roan antelope, warthog, buffalo, greater kudu and red fromted gazelle. Many birds are found in the park such as ostrich, marabou stork, Clappertoni francolin, cattle egret, crowned crane, grey heron, sacred ibis, hooded vulture, pink backed pelican, bee-eaters, starling and guinea fowl. The annual reports on the park show continuous decline in the population size of nearly all species.

## 2.2 POLICIES, LEGISLATIONS, INSTITUTIONAL FRAMEWORKS AND INTERNATIONAL AGREEMENTS

Countries of the Eastern Nile Basin have been formulating, adopting and implementing policies and legislations that could combat the problems of environmental degradation and water qualities.

To this effect:

- Relevant institutions have been created;
- International agreements have been signed; and
- Action plans have been prepared.

### 2.2.1 National Environmental and Water Policies, and Action Plans

#### 2.2.1.1 Environmental Policy in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

The constitutions of Sudan and Ethiopia recognize the importance of the environment, the need for its proper management and protection. These provisions have become the major springboards for the subsequent issuance of environmental management legislations.

The environmental policies generally aim at improving and enhancing the health and quality of life of the people to promote sustainable social and economic development through sound management and use of natural resources and the environment as a whole. However, it should be noted here that even though the policies consist of lists of sectoral and cross-sectoral policies, evaluation of their implementation has hardly been carried out.

In the Sudan, for instance, the following are examples of relevant national policies and strategies:

- The 25 Years Strategic Plan (2003-2027);
- The National Comprehensive Strategy (1992-2002);
- National Economic Salvation Program (1992-1993);
- The Joint Assessment Mission;
- Poverty Reduction Strategy; and
- National Water Policy

#### 2.2.1.2 Water Policy in the Main Nile (Egypt)

The Ministry of Water Resources and Irrigation in the Main Nile (Egypt) has prepared a National Water Policy that lasts till the year 2017 with the following three main themes.

- Optional use of available water resources;
- Development of water resources; and
- Protection of water quality and pollution abatement.

The Optional Use of Available Water Resources embodies the strategies to achieve optimum use of all available water resources through:

- Minimizing water loses;
- Irrigation improvement projects;
- Shifting cropping patterns;
- Ground water development strategies;
- Reuse of agricultural drainage water; and
- Reuse of sewage water.

Water Resources Development theme involves:

- The country's increased share of the Nile water;
- Desalination of brackish water; and
- Harvesting of rainfall and flash floods water.

Water Quality Protection and Pollution Abatement seeks:

- Policy theme that can be realized through preventive measures and long-tern policies;
- Water quality management;
- Economic instruments that include encouraging private sector participation and adopting the polluter pay principle;
- Coastal lakes management;
- Coastal water management scheme;
  - Drinking water management (control of water losses, poor quality of drinking water and high domestic water consumption);
  - Water quality management program;
  - Waste water management of:
    - Domestic waste water;
    - Agriculture waste water; and
    - Industrial wastewater and
  - Sanitation management program

### 2.3 ENVIRONMENTAL REGULATORY AND LEGISLATION

#### 2.3.1 Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

In the upper parts of the sub-basins, the environmental policy has been legally enforced through the approval of the policy by the Council of Ministers. The sectoral and cross-sectoral issues in the policy are concerned with

- Improved soil management and sustainable agriculture;
- Forest and tree resources management;
- Genetic, species and ecosystem biodiversity conservation and management;
- Water resources development;
- Improvement of urban environment and environmental health;
- Control and management of pollution from industrial waste and hazardous materials;
- Control of atmospheric pollution and climate change; and
- Conservation and protection of cultural and natural resources.

Three different proclamations have been drafted and enacted. They are:

- Proclamation for the Establishment of Environmental Protection Organs;
- Environmental Pollution Control Proclamation; and
- Environmental Impact Assessment Proclamation.

In addition to these proclamations, the Council has also approved other laws, environmental guidelines and standards.

In the lower part of the sub-basins, the Higher Council for Environment and Natural Resources (HCENR) has initiated the development of environmental regulations called the Environment Protection Act, which has been issued through a presidential decree. Guidelines and requirements have been established for environmental impact assessments and environmental conservation frameworks. The environmental protection policy requires that any new projects that are deemed to have an impact on the environment have to conduct an Environmental Impact Assessment.

#### 2.3.2 Environmental Legislation in the Main Nile (Egypt)

There is a wide variety of legislation in Main Nile (Egypt) for the control of the impact of human activity on the environment. Such environmental legislation is concerned with surface water contamination, soil pollution and degradation, air contamination, noise, energy consumption and effects on human beings and other living organisms.

The following are laws controlling water pollution in country of the Manin Nile:

- **Law 48/1982** prohibiting discharge to river Nile, irrigation canals, drains lakes and ground water without a license. Licenses can be issued as long as the effluents meet the standards of the law. The license includes both the quantity and quality that is permitted for discharge;

- **Law 4/1994** allowing the preparation of legislation and decrees to protect the environment in the country. The Environmental Agency also has the responsibility for setting standards and carrying out compliance monitoring.

In the region, environmental laws have not been enforced adequately for a variety of reasons, including:

- Lack of adequate authorities with necessary resources to carry out inspection and enforcement;
- Lack of public awareness regarding the magnitude of the environmental problems and their negative effects;
- Ineffectiveness of the regulatory approach to allow the flexibility necessary for the polluter and the regulatory agency to negotiate quick agreement on a compliance schedule;
- Concentration of regulators on informing the polluter of a violation, without provisions for phasing in compliance measures after the violation has been announced; and
- Insufficient coordination and cooperation among the ministries and governmental institutions regarding the issue of environmental protection.

## 2.4 INSTITUTIONAL FRAMEWORKS AND INTERNATIONAL AGREEMENTS

### 2.4.1 Institutional Framework

#### 2.4.1.1 Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

In the upper part of the sub basins (Ethiopia), an institution to protect the environment called Environmental Protection Authority (EPA) was established in 1995. At the federal and regional states levels, there are several institutions engaged in natural resource protection, development and research. The Following are the major ones:

- Ministry of Rural Development;
- Ministry/Bureau of Agriculture;
- Ethiopian Wildlife Development and Protection Organization;
- The Ethiopian Agricultural Research organization as well as agricultural research institutions in most of the regional states;
- Ministry of Water Resources and Regional water and Energy Bureaus;
- Institute of Biodiversity Conservation and Research;
- Disaster Prevention and Preparedness Agency and Regional Disaster Prevention and Preparedness Bureaus; and
- Rural Energy Development Promotion Centre.

In addition to the above institutions, there are quite a number of non-governmental organizations, civil society institutions and trade associations that are involved in environmental protection, conservation and related activities.

In the lower part of the sub basins (Sudan), there are environmental institutions such as:

- The Higher Council for Environment and Natural Resources (HCENR),
- Wildlife Conservation General Administration (WCGA),
- Institute of Environmental Studies (IES), University of Khartoum,
- Non Governmental Organizations:
    - Sudanese Environmental Conservation Society (SECS); and
    - Sudanese Social Forestry Society (SSFS).

#### 2.4.1.2 Main Nile (Egypt)

The institutions involved with water quality management in Egyptt are generally line-ministries with responsibilities in areas that are related to, but not necessarily coincident with, environmental protection.

The following are institutions with major roles in water quality management:

- Ministry of Water Resources and Irrigation (MWRI);

- Egyptian Environmental Affairs Agency (EEAA);
- Ministry of Health and Population (MoHP);
- Ministry of Housing, Utilities and New Communities MHUNC);
- Ministry of Agriculture and Land Reclamation (MALR);
- Ministry of Industry (MOI);
- Ministry of Higher Education and Scientific Research (MHESR);
- Ministry of Interior; and
- Non-governmental Organizations.

### 2.4.2 International Agreements

Regarding international agreements and their implementation, the country constituting the upper part of the sub basins (Ethiopia) has adopted and ratified several conventions and agreements related to the environment, namely:

- Convention on Biodiversity;
- The united Nations Convention to Combat Desertification;
- The Vienna Convention for the Protection Of The Ozone Layer;
- Framework Convention on Climate Change;
- The Basel Convention: A Convention to Control and Regulate the Trans Boundary Movement of Hazardous Waste;
- The Stockholm Convention: A Convention Designed to Ban the Use of Persistent Organic Pollutants (POPs);
- The Rotterdam Convention, relating to the prior informed consent in the context of international trade in specific hazardous chemicals and pesticides; and
- International Convention on Trade in Endangered Species, Fauna And Flora.

In response to multilateral agreements, the Government in the lower part of the sub basins (Sudan) has developed a number of national strategies that include the following:

- Agenda 21 project-Sudan: a response to the Rio Earth Summit 1992;
- National Biodiversity Strategy and Action Plan (NBSAP);
- Towards national Implementation Strategy for the UN Framework Convention on Climate Change;
- Assessment of Impacts and Adaptation to Climatic Change;
- National Action Plan to Combat Desertification; and
- Persistent Organic Pollutants.

### 2.4.3 Other Environmental Issues

#### 2.4.3.1 Environmental Programmes and Projects

The following projects either have been already implemented or are in the process of implementation the upper part of the three sub basins (Ethiopia):

- Project for the Control and Disposal of Expired Pesticides;
- Project for the Preparation of a National Chemical Handling and Registration guideline;
- The Ecologically Sustainable Industrial Development Project;
- The National Cleaner Production Centre Project;
- The Amhara Region Sustainable Development Project;
- The Energy and Woody Biomass Survey Project;
- The Addis Ababa Industrial Zone Cost Benefit Analysis Project;
- The Tannery Pollution Control Project;
- The Project for the Generation of Employment for Women Fuel-wood Carriers;
- The Project for the Environmental Auditing of 10 Factories; and
- The Federal and Regional Conservation Strategies.

#### 2.4.3.2 Environmental Information System

In the area of environmental information system**,** there is no efficient and consistent environmental information system in the whole range of the sub basins. Data from diverse sources of different times and various purposes are less compatible and lack consistency in time and space. However, efforts are being made at the different environmental authorities to organize systematic environmental information.

#### 2.4.3.3 Environmental Education/Knowledge in the Main Nile

Education and awareness as essential tools in highlighting the importance of environmental protection have been recent initiatives aimed at enhancing and developing environmentally literate citizens who share a concern for environmental protection issues in the region. It is aimed that environmental awareness could be realized through introducing environmental education and training programs on both formal and informal levels of education.

Egyptian Environmental Affairs Agency (EEAA), realizing the importance of raising the public's environmental awareness, is providing continuous support to environmental training and awareness activities and initiatives. This is reflected in the protocol between the Ministries of Education and Environment signed in 1999.

## 2.5 ENVIRONMENTAL STATUS, THREATS AND DAM SAFETY IN TEKEZE- ATBA-SETIT, BARO-AKOBO-SOBAT-WHITE NILE, AND BLUE NILE

### 2.5.1 Environmental Status and Threats

The causes of environmental threats are interconnected. Land degradation is the result of deforestation and inappropriate agricultural practice. As mentioned earlier, the main cause of deforestation in those regions is the increasing need for forest products by the rapidly growing rural and urban population. Soil loss, due to removal of the vegetation cover, is an ever-increasing problem. As a result, in upper part of the sub basins (Ethiopia) for instance, up to 400 tons of fertile soil per hectare is lost annually from lands devoid of vegetative cover as well as from lands where no soil conservation has been carried out. About 130 metric ton of soil per year is lost within the upper part of Blue Nile sub-basin alone.

In the lower part of the sub basins (Sudan) Environmental Degradation and Floods remain the major environmental problems. Sudan was ranked among the 10 bottom countries in the 2005 Environmental Sustainability Index (ESI). This reflects a low environmental performance taking the five standard measurement components (Environmental System, Reducing Environmental Stresses, Reducing Human Vulnerability, Social and Institutional Capacity, Global Stewardship levels that cause no serious harm.)

The key driving forces of environmental degradation in the lower part includes climatic variability and change, which is explained in the form of severe drought and occasional floods. Climate change is expected to increase the frequency and severity of climatic variability.

In general, the following conditions characterize the environments in three sub-basins:

- **Land degradation** happens as the result of many factors such as ad hoc government policies regarding the use of natural resources, horizontal expansion of rain fed mechanized and traditional farming, heavy reliance on forest biomass energy, overgrazing, bush fire, etc.;
- **Unsuitable agricultural practices** are manifested in the form of reliance on seasonal bush and grassfires for purposes of preparing land for cultivation, pastoralism, overgrazing in some regions and limited extension services;
- **Wetland loss and degradation** results through direct drainage for cultivation, grazing, etc., or indirectly through sedimentation and pollution;
- **Loss of soil nutrients** becomes a phenomenon due to mono-cropping farming system, years of extensive cultivation practices by the mechanized and traditional rain feed sectors, with limited or no access to fertilizers and improved farming techniques compounded by wind and water erosion which left most soils to nutrient depletion;
- **Deforestation** has continued as a result of encroachments, agricultural activities and urbanization. Forest resources have also depleted as a consequence of uncontrolled felling of trees;
- **Desertification** has become a growing challenge, which affected significant part of the regions' land area. In the lower part, the largest portion ranges from light to severe

desert where about 13 of the 26 states in Sudan could be classified as desert or semi-desert;

- **War and civil strife** had tremendous impacts on the natural resources and the entire environment; and
- **Increased population pressures and urbanization** entailed more demand on resources and services.

### 2.5.2 Dam Safety

As far as the dam safety is concerned in the lower part of the three sub basins, accumulation of silt in the dam lakes has reduced the storage capacity of dams constructed to store water for irrigation and generation of hydroelectric power. As a result, new dams are being constructed to store water for irrigation. This, however, will have environmental impacts and can displace a number of people. On top of that, farmers of the downstream may not get fertile soil coming from the upstream as before. The consequence would be that a number of farmers would be forced to use fertilizers that make agricultural products more expensive and have negative effects on the environment at large.

As to the biodiversity, about 115 species of fish belonging to 27 families have been identified. The threats facing the Blue Nile fisheries are the illegal fishing and operation of beach seines. Furthermore, there is unconscious use of poison in fishing operations.
From the viewpoint of the environmental impact, there is spread of water plants that assisted the spread also of the bilharzias vectors, which infect a very high percentage of the population. The impact in this case is connected to the Gezira irrigation scheme of cotton production, in which extensive network of canals has been created resulting in stagnant pools of water.

### 2.5.3 Water Quality Problems in the Main Nile Sub Basin

The major environmental problems of the Main Nile area water quality, water-borne diseases, unsuitable agricultural practices, soil degradation and contamination, tthreats to the biodiversity and desertification.

The main water resource in Egypt is the River Nile, which constitutes 96percent of the renewable water resources. The protection of water resources is one of the most critical environmental issues.. However, the major water quality problems in that part of the Eastern Nile sub-basin are pathogenic bacteria/parasites, heavy metals and pesticides, whose major sources are the uncontrolled discharge of human, industrial and agricultural wastes.

Agriculture is the major source of pollution, with a number of potential impacts on the environment and human health. The main impacts of agriculture on water quality are:

- Increase in salinity,
- Deterioration of quality due to infiltration of fertilizers and pesticides; and
- Possible eutrophication of water bodies resulting from increase in nutrients from fertilization.

In order to overcome the water quality problems, a number of water treatment systems have been put in place. Two types of wastewater treatment systems, namely: aerobic and anaerobic have been put in practice.

Throughout history, epidemics related to water borne or water-related pathogens have plagued in the Egypt basin. The pathogens are salmonella, Shigella, Vibrio cholera, parasites, hepatitis A virus, hepatitis E virus, viral gastroenteritis and poliomyelitis virus.

There are a number of factors that are responsible for contamination of waters in the sub-basin. Available information indicate that 80 percent of the urban population in the sub-basin is reported to have acceptable sanitation, including toilet facilities, while 77 percent of the urban population is connected to public sewers. However, in rural areas, only 5 percent of the population is connected to sewers; and as low as 25 percent is considered having some sanitary facilities.

About 20 percent of the total population (5 percent urban and 25 percent rural) lacks safe public drinking water supplies and rely instead on potentially contaminated, untreated surface water or hand pumps, which tap often contaminated shallow groundwater.

Not all the existing sewage treatment facilities are providing complete secondary treatment of wastewater, and the effluents discharged are either partially treated or left untreated, especially in the rural areas. In addition, many industries combine their wastes with sewage and discharge them into fresh waterways. The contaminated discharge of agricultural drain waters into fresh waterways constitutes a health hazard due to faecal contamination and the presence of pathogenic organisms.

In other cases, agricultural practices have had the greatest impact on the environment of the Lower end of Eastern Nile. These have been reflected in water logging and salinization caused by irrigation schemes. Increased application of chemical fertilizers also poses widening environmental damages.

Pollutants carried by irrigation water are the major source of soil pollution leading to loss of productivity in agricultural land. Severe damage to plants has been reported in areas close to industries such as toxic heavy metals accumulation in the tissues of vegetation.

Biodiversity in the lower end has faced threats from various sources. These include intensive agriculture systems, effects of industrialization, excessive hunting of animals and destruction of plant life, all of which have endangered the existence of several species of resident and migratory birds and hoofed animals. As a result, the country is now exerting tremendous effort to combat the threats to biodiversity through the conservation of wildlife, natural resources and natural habitat.

The desertification of irrigated agricultural lands in the Lower end is the result of various practices and factors. There are two main practices, namely: urban development and building on fertile agricultural lands. Furthermore, other factors include despoliation of agricultural land through surface layer erosion of soils, pollution of soil from wastewater, use of pesticides and chemical fertilizers, and the salinization of the agricultural soil.

## 2.6 IMPACTS OF MAJOR DEVELOPMENT OPPORTUNITIES, PROGRAMS AND PROJECTS

### 2.6.1 Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

In the particular case of the upper part of the sub basins, the major areas of development that are given due attention are irrigation and hydropower development. Both activities could have direct and indirect impacts on the upstream and the downstream areas of all sub basins.

The hydropower and irrigation projects are expected to create a range of direct and indirect impacts including the following:

- Disruption of settlement areas and loss of agricultural lands;
- Land allocation conflicts, habitat destruction, erosion and changes in water table;
- Excessive watershed erosion;
- Upstream deterioration in water quality;
- Downstream flow variation;
- Environmental and social enhancement due to new reservoir fishing industries, draw-down agricultural activates, downstream community water supply, forestry and wildlife reserves and rural electrification;
- Inundation losses of primary forests;
- Infrastructure loss;
- Impediments to movement of wildlife, livestock and people;
- Changes in routes of transmission lines; and
    - Prevalence of diseases like malaria, schistosomiasis and other geohelminthic due to the construction of micro-dams.

I the lower part, it is estimated that only 30 percent of the population has access to electricity. In response, projects are underway to add both fossil-fueled and hydropower generating capacity. The largest of these projects are the proposed Kajbar hydroelectric facilities in northern Sudan that are expected to generate 1,250 MW and 300 MW of electricity respectively.

Hydropower production and transmission of electricity, however, are expected to create diverse and substantial environmental and socio-economic impacts. Currently, the electrical industry in that part of the Nile basin is being subjected to a very strong public pressure to minimize its potential negative impacts and improve its social and environmental performance. On the other hand, hydropower is currently the major renewable source contributing to electricity supply, and its future contribution is anticipated to increase significantly.

### 2.6.2 The Main Nile (Egypt)

*The impacts of development projects (both positive and negative) in the Main Nile in Egypt may not be significantly different from those of the middle and upper courses of the Eastern Nile Basin. However, this part has not been covered by the consultant who compiled the initial information on the Main Nile in Egypt.*

## 2.7 INSTITUTIONAL CONSTRAINTS, DATA QUALITY AND GAPS

### 2.7.1 Comments on Data Quality

The environmental policies in the sub basins seems to be relatively older in view of the structural and institutional changes that have apparently taken place since the issuance of those policies. In spite of the constitutional considerations for environmental protection, the strength of legal backing and institutional functionalities within the environmental protection activities may seem to be less clear in the documents.

However, from the data and information perspective, the basin master plan studies in the upper parts (in Ethiopia) form the most important and relevant components of the environmental datasets, in which the natural resources aspect of the physical environment has been treated well and information collected in those regards have been found invaluable in respect of the data poverty in many parts of the eastern Nile basin.

In spite of this, most of the important data sets and information are relatively older to explain current and short-term conditions in the sub-basins. At the sub-basin level, the doubts on the effectiveness of those datasets may worsen if studies on the pressing issues like land degradation, erosion hazards, soil loss, deforestation, flooding, and other environmental threats are considered.

It is known that the sub basins are characterized mainly by greater population pressure on natural resources, including land. In the sub-basin, extensive cultivation and encroachments into areas of natural vegetation may inevitably result in further deforestation, severe erosion hazards and continued loss of soils.

In the other case, no study and report in the sub basins adequately disclosed the potentials for aquatic resources, the state of wetlands and wild life habitants. Some of the datasets made available have happened to be incomplete. The worst scenario is the absence of environment related spatial datasets describing past trends, current situations and future outcomes in the general environment of the entire Eastern Nile Basin. In the area of information resources, many studies and surveys conducted indicated the gap in information regarding the status of environment and natural resources. For example, the National Forest Inventory conducted by the Forests National Corporation (FNC) and FAO in 1995 did not include southern Sudan because of the instability and civil conflicts.

Apart from the prevailing data and information gaps, the problems of natural management could be attributed to shortcomings related to institutions, including policies, human and institutional capacities, finance, knowledge, etc.

In the area of institutional capacity, a number of decrees and legislation that could have largely contributed to sustainable management of natural resources remain unimplemented. The threat could emanate largely from lack of strong implementation or/and enforcement mechanisms of government policies and legislations.

Furthermore, government institutions remain deprived of the necessary budgetary resources that would enable to provide basic services and perform other duties and responsibilities.

In addition, it has also been reported that successive wave of brain drain has significantly contributed to deprivation of well-trained human resource base and skilled personnel.

In the particular case of the Main Nile in Egypt, despite the involvement of twenty-five agencies in water quality monitoring program, there are many gaps that could be outlined as follows:

- All monitoring programs focus only on the conventional parameters and do not cover the sediment and fish samples. Moreover, very limited data is available about the micro-pollutants (pesticides, heavy metals and hydrocarbons);

- The essential components for effective environmental monitoring lack consistency and continuity. In Egypt, there are many governmental and academic bodies collecting data but it is rare to find full comparability among the data from different sources. Moreover, environmental data need consistency and continuity over time because it is generally all about changes, deterioration or improvement of interest. Many Egyptian data sets have begun as part of development project supported by donor funds. Unfortunately, many lapses occur once foreign-assisted projects are completed

- There is a lack of inter-ministerial co-operation and data sharing. Many available reports related to water quality issues relied on old water quality data, which reduce the benefit of these studies;

- Another important concern is the reliability and validity of the data. In view of the lack of uniformity among the various measurement programs, available data exhibit both random and systematic errors.

## 2.8 GENERAL RECOMMENDATIONS

In light of mitigating the adverse environmental impacts and enriching environmental information on the Eastern Nile basin, the following issues need to be considered:

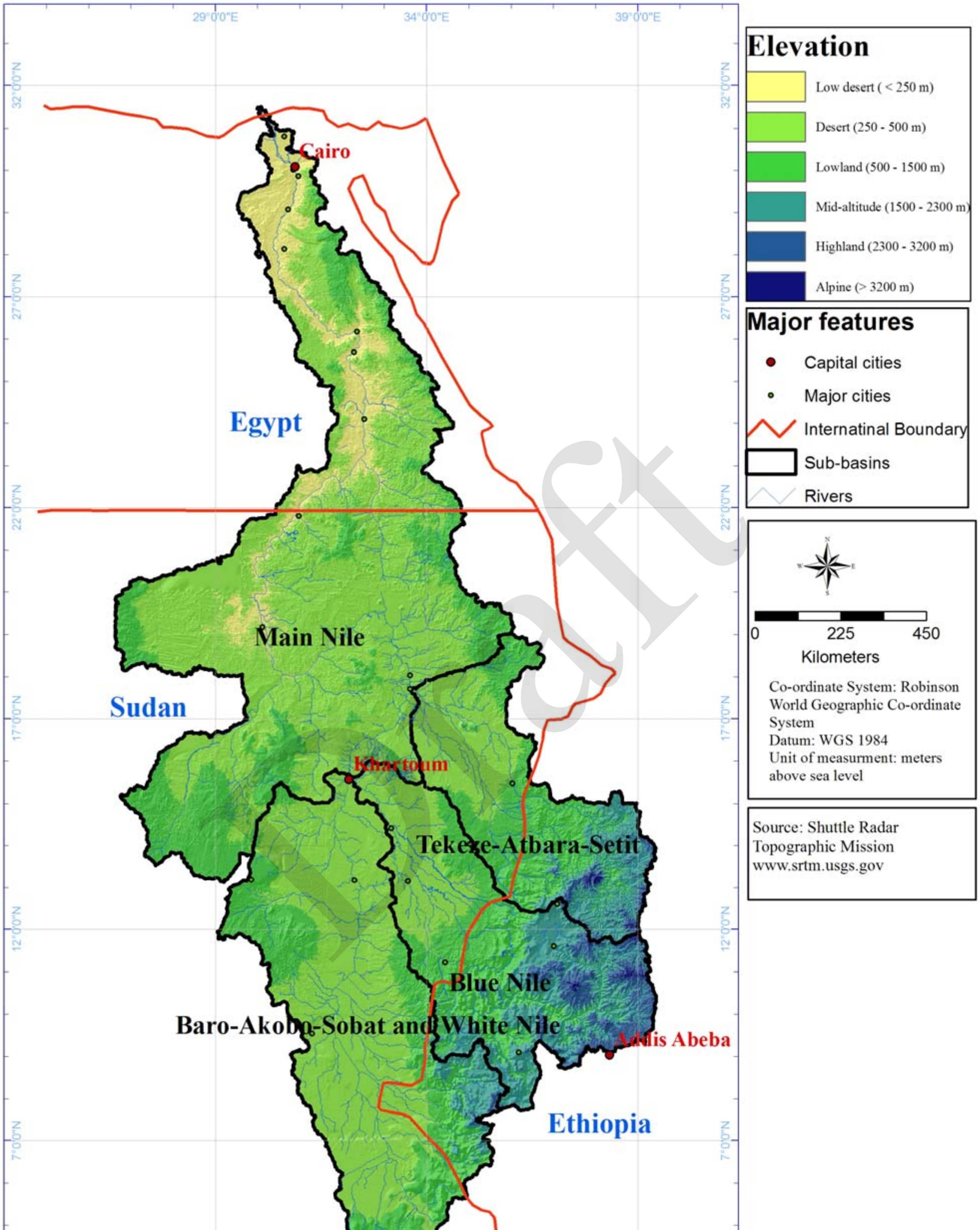
- Opportunities and constraints related to sustainable management of natural resources need to be examined in a holistic and balanced manner;
- Multi-purpose development projects should be based on environmentally sound national and regional guidelines that are based on the national development policies and strategies of the riparian countries;
- The decisions on multi-purpose development project should consider the range of benefit and impacts (economic and non-economic) to the society as well as of the environmental costs and benefits;
- Special consideration should be given to important ecosystems;
- The need for the early detection of any environmental changes resulting from the development project requires that an efficient monitoring system supported by periodic inventories be put in place;
- ENTRO should promote and provide opportunities for the broader participation of different stakeholders;
- In spite of information gaps mentioned earlier, it is hoped that this synthesis should be enriched and advanced by more important environmental information and further studies;
- As most of the information in this document are almost outdated, it would be necessary for ENTRO to conduct General Baseline Environmental Studies of the sub basins;
- It is strongly recommended that ENTRO should seriously consider the collection, organization, standardization, integration and analysis of environment-related spatial data particularly from Sudan and Egypt, in order to make use of the large volume of same datasets collected on the sub-basin in Ethiopia. Failures in this regard my further limit the

progress of specific studies and strain the strength of the plans to be formulated and the decisions to be made within the Joint Multi-Purpose Programs (JMP).

- ENTRO needs to consider that the content and strength of the initial One-System-Inventory (OSI) have been weakened due to the focus of the information on the Main Nile in Egypt on the water quality without giving adequate treatment to other environmental issues. In that regard, future data compilation and analysis may be required.

**Annex Maps for Executive Summary:**

a) Elevation classes in the sub basins of the East Nile;
b) Slope gradients in the sub basins of the East Nile;
c) Land cover distribution in the sub basins of East Nile;
d) Rainfall distribution in the sub basins of East Nile;
e) Mean annual temperature in the sub basins of East Nile;
f) Major soil types in the sub basins of East Nile;
g) Soil Erosion hazards in the sub basins of East Nile.



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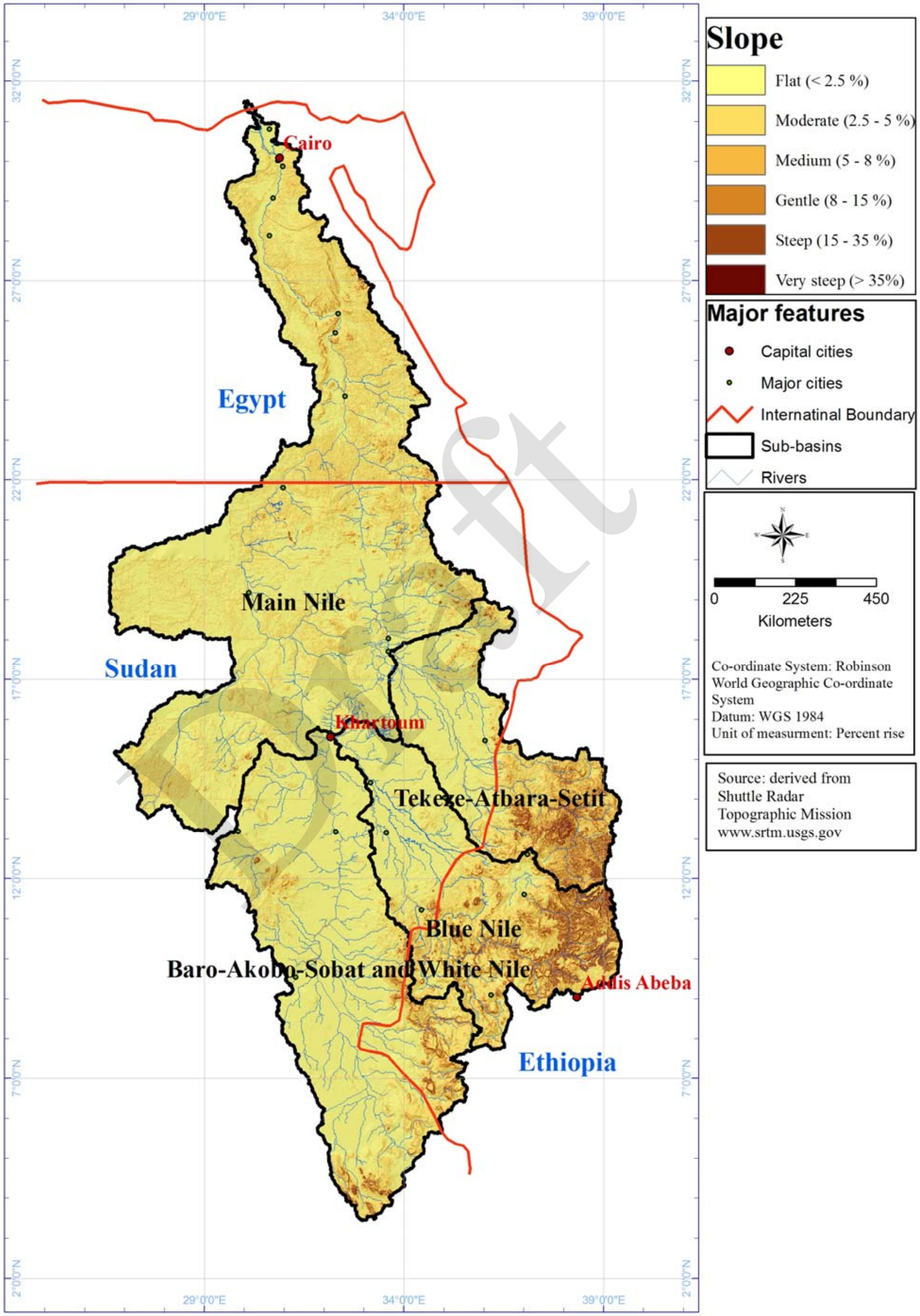
Cairo
Egypt
Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
Draft
Elevation
Low desert ( < 250 m)
Desert (250 - 500 m)
Lowland (500 - 1500 m)
Mid-altitude (1500 - 2300 m)
Highland (2300 - 3200 m)
Alpine (> 3200 m)
Major features
Capital cities
Major cities
Internatinal Boundary
Sub-basins
Rivers
0
225
450
Kilometers
Co-ordinate System: Robinson World Geographic Co-ordinate System
Datum: WGS 1984
Unit of measurment: meters above sea level
Source: Shuttle Radar Topographic Mission www.srtm.usgs.gov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Cairo
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Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
Slope
Flat (< 2.5 %)
Moderate (2.5 - 5 %)
Medium (5 - 8 %)
Gentle (8 - 15 %)
Steep (15 - 35 %)
Very steep (> 35%)
Major features
Capital cities
Major cities
Internatinal Boundary
Sub-basins
Rivers
0
225
450
Kilometers
Co-ordinate System: Robinson
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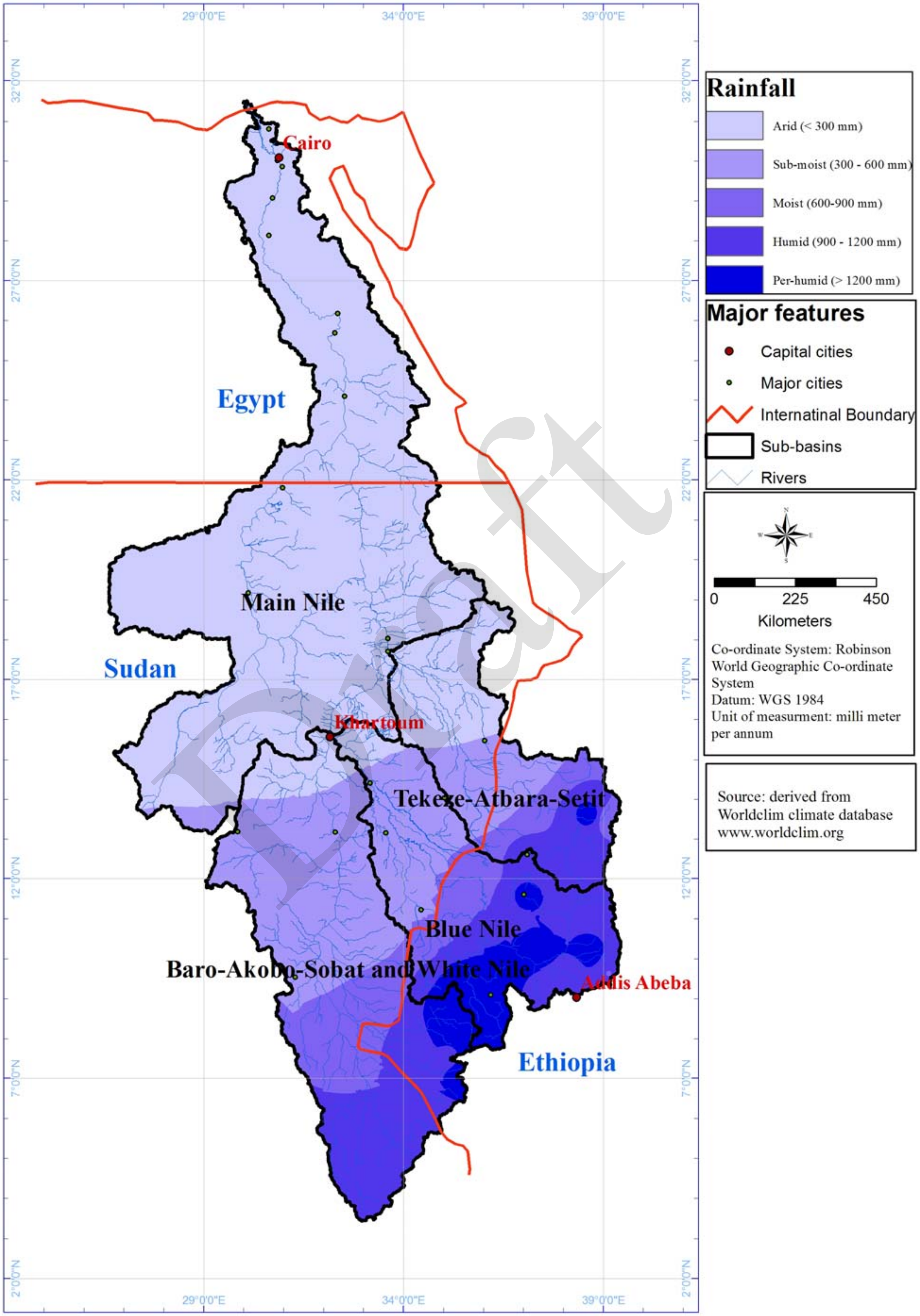
Datum: WGS 1984
Unit of measurment: Percent rise
Source: derived from Shuttle Radar Topographic Mission www.srtm.usgs.gov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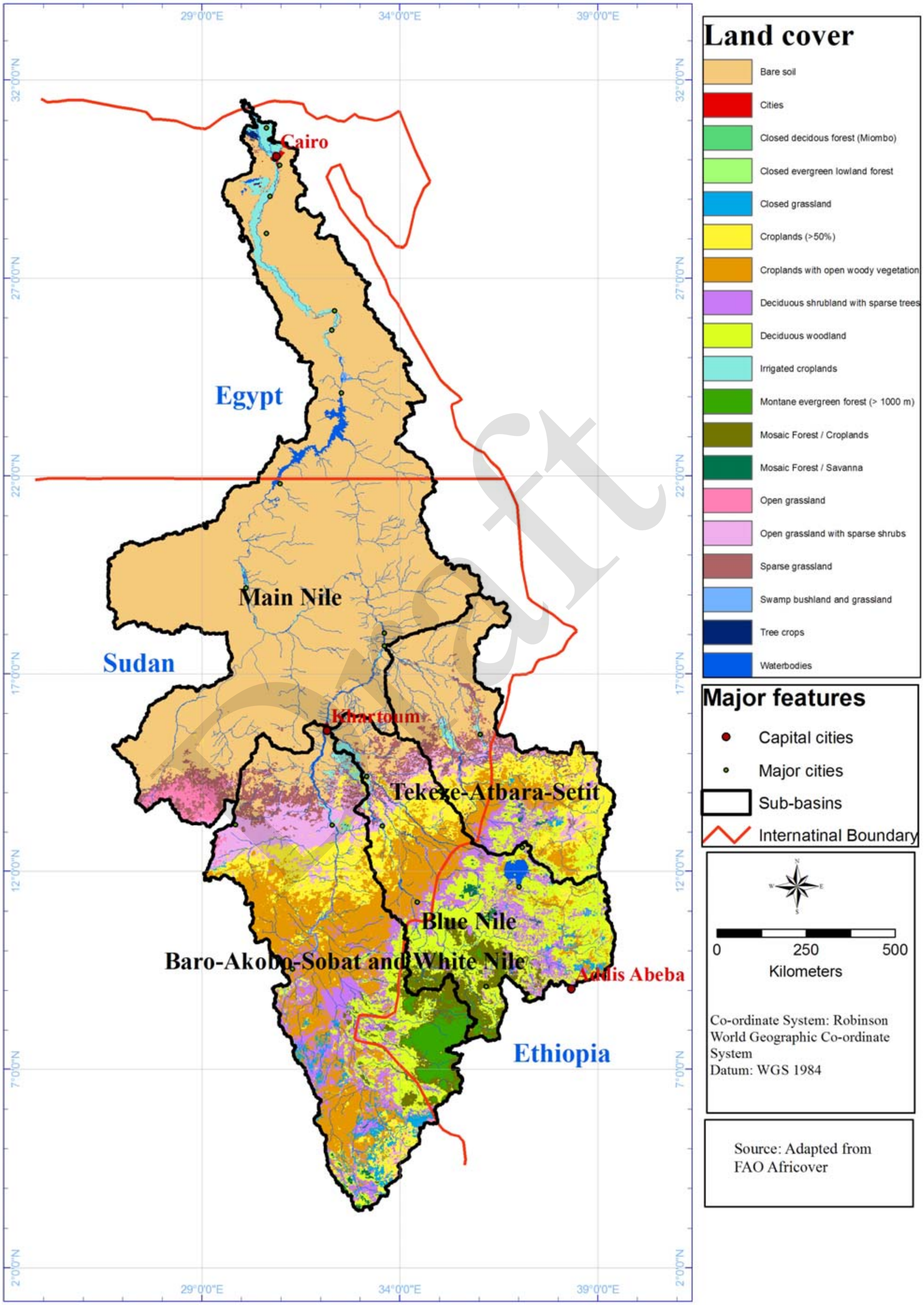
Cairo
Egypt
Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
Draft
Rainfall
Arid (< 300 mm)
Sub-moist (300 - 600 mm)
Moist (600-900 mm)
Humid (900 - 1200 mm)
Per-humid (> 1200 mm)
Major features
Capital cities
Major cities
Internatinal Boundary
Sub-basins
Rivers
0
225
450
Kilometers
Co-ordinate System: Robinson World Geographic Co-ordinate System
Datum: WGS 1984
Unit of measurment: milli meter per annum
Source: derived from Worldclim climate database www.worldclim.org



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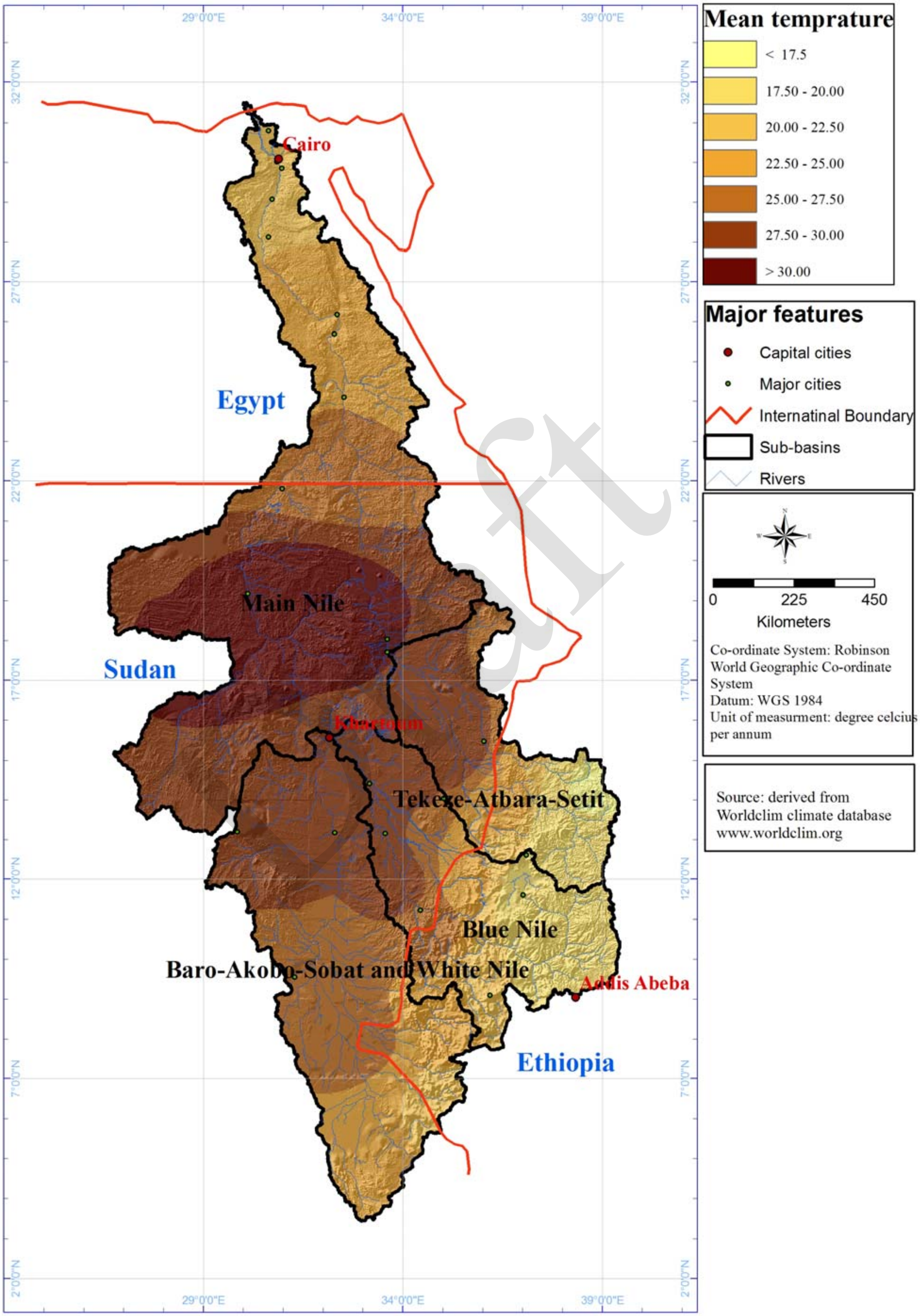
Cairo
Egypt
Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
Land cover
Bare soil
Cities
Closed decidous forest (Miombo)
Closed evergreen lowland forest
Closed grassland
Croplands (>50%)
Croplands with open woody vegetation
Deciduous shrubland with sparse trees
Deciduous woodland
Irrigated croplands
Montane evergreen forest (> 1000 m)
Mosaic Forest / Croplands
Mosaic Forest / Savanna
Open grassland
Open grassland with sparse shrubs
Sparse grassland
Swamp bushland and grassland
Tree crops
Waterbodies
Major features
Capital cities
Major cities
Sub-basins
Internatinal Boundary
0
250
500
Kilometers
Co-ordinate System: Robinson
World Geographic Co-ordinate
System
Datum: WGS 1984
Source: Adapted from
FAO Africover
Draft


Mean temprature
< 17.5
17.50 - 20.00
20.00 - 22.50
22.50 - 25.00
25.00 - 27.50
27.50 - 30.00
> 30.00
Major features
Capital cities
Major cities
Internatinal Boundary
Sub-basins
Rivers
0
225
450
Kilometers
Co-ordinate System: Robinson World Geographic Co-ordinate System
Datum: WGS 1984
Unit of measurment: degree celcius per annum
Source: derived from Worldclim climate database www.worldclim.org
Cairo
Egypt
Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
29°0'0"E
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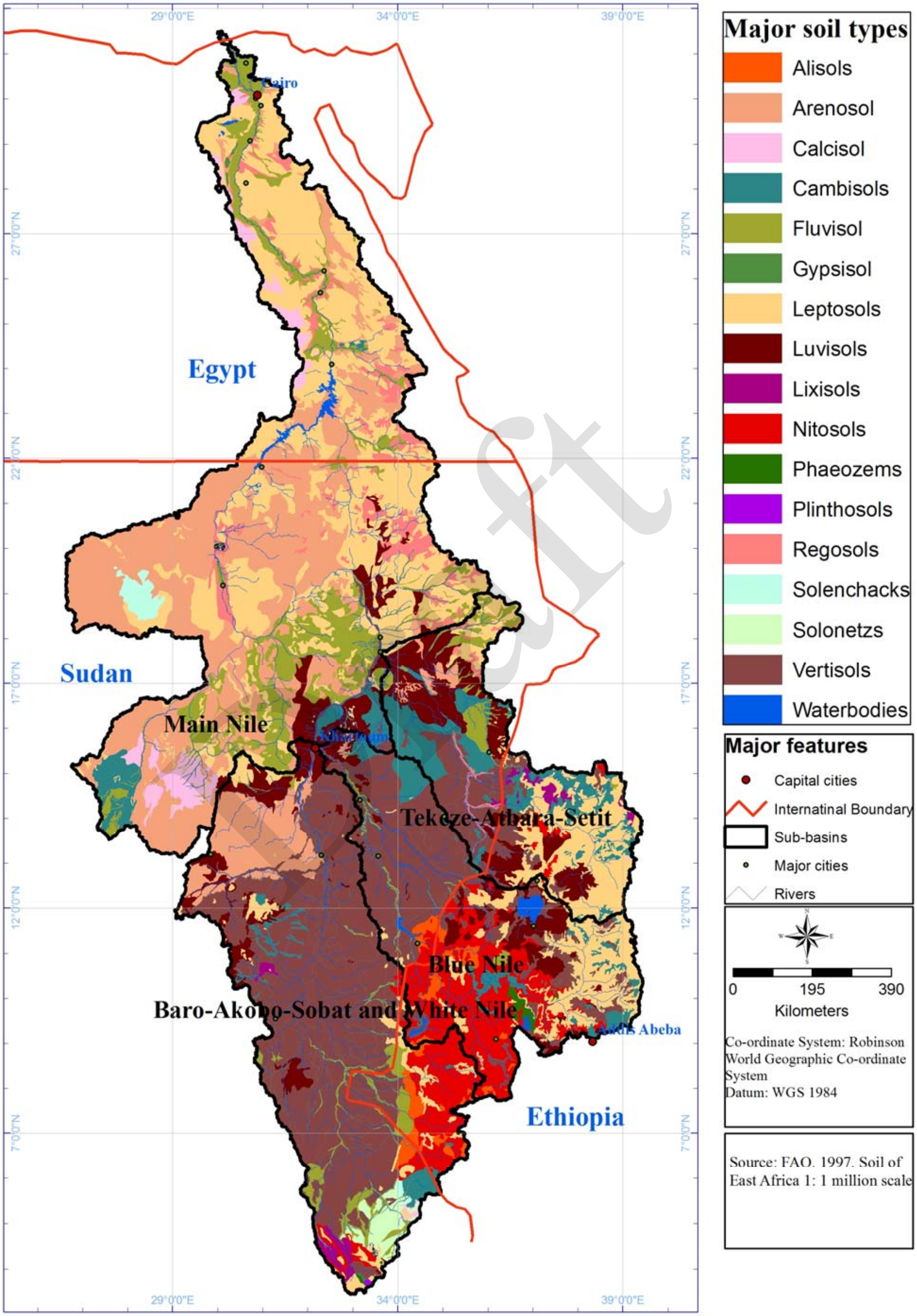

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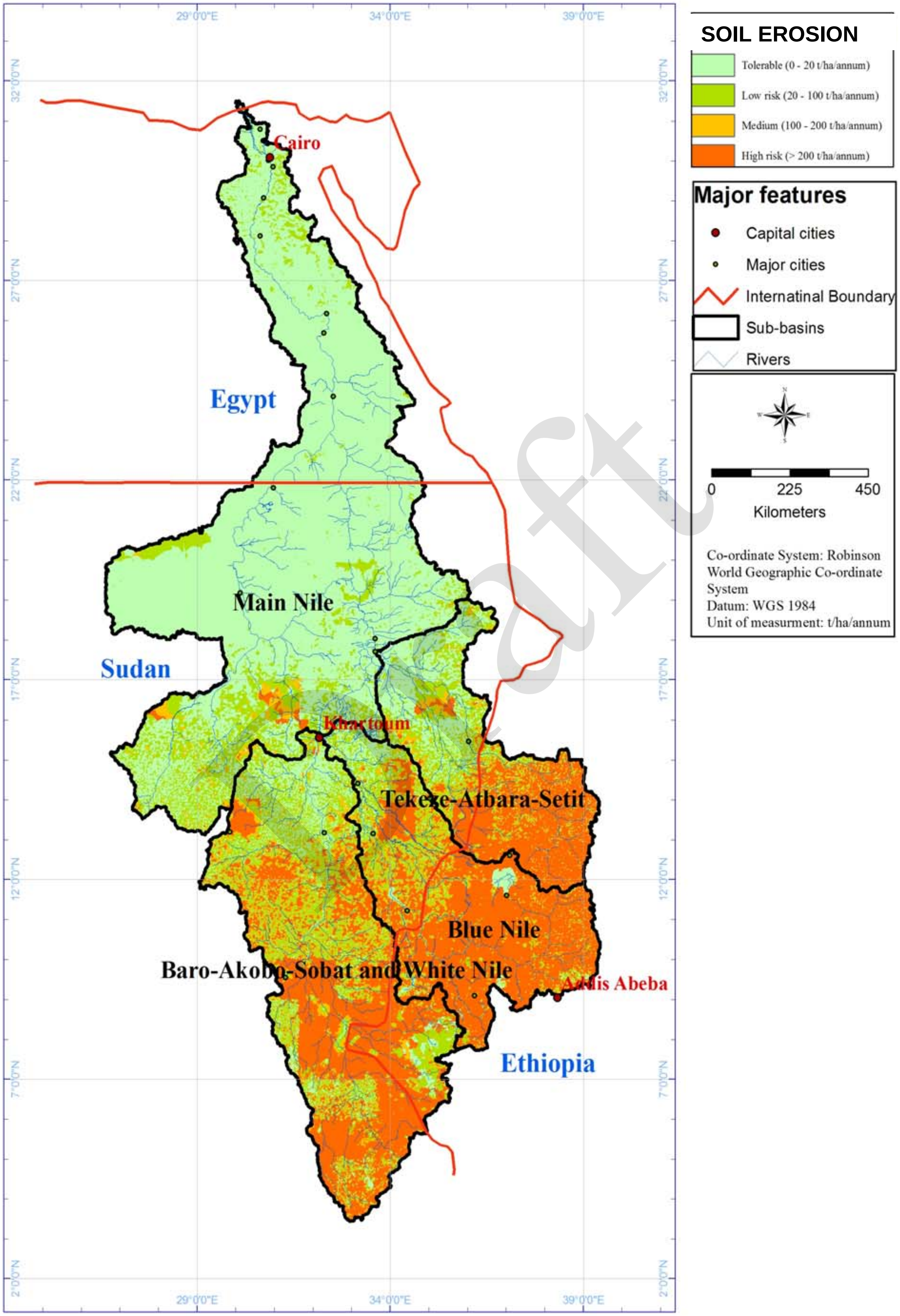
Cairo
Egypt
Sudan
Main Nile
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia
Major soil types
Alisols
Arenosol
Calcisol
Cambisols
Fluvisol
Gypsisol
Leptosols
Luvisols
Lixisols
Nitosols
Phaeozems
Plinthosols
Regosols
Solenchacks
Solonetzs
Vertisols
Waterbodies
Major features
Capital cities
Internatinal Boundary
Sub-basins
Major cities
Rivers
0
195
390
Kilometers
Co-ordinate System: Robinson World Geographic Co-ordinate System
Datum: WGS 1984
Source: FAO. 1997. Soil of East Africa 1: 1 million scale


SOIL EROSION
Tolerable (0 - 20 t/ha/annum)
Low risk (20 - 100 t/ha/annum)
Medium (100 - 200 t/ha/annum)
High risk (> 200 t/ha/annum)
Major features
Capital cities
Major cities
Internatinal Boundary
Sub-basins
Rivers
0
225
450
Kilometers
Co-ordinate System: Robinson World Geographic Co-ordinate System
Datum: WGS 1984
Unit of measurment: t/ha/annum
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2°0'0"N
Cairo
Egypt
Main Nile
Sudan
Khartoum
Tekeze-Atbara-Setit
Blue Nile
Baro-Akobo-Sobat and White Nile
Addis Abeba
Ethiopia

# 3. ENVIRONMENTAL ASSESSMENT OF EASTERN NILE BASIN

## 3.1 Baro-Sobat-White Nile Sub-Basin

### 3.1.1 Location and Area

The sub-basin has an area of 468,216 km$^2$, accounting for about 28.3% of the total area of Eastern Nile Basin. The Baro-Sobat-White Nile sub-basin covers 76,742 Km$^2$ in Ethiopia, which is about 16% of the sub-basin, while 391,474 km$^2$ or about 85% of the sub basin's total area is located in the Sudan.

Baro-Sobat-White Nile sub-basin covers parts of Oromia, Benishangul-Gumuz, Southern Peoples' Region and Gambella states in Ethiopia and a number of states in the Sudan that include Gezira, Sinnar, White Nile, East Equatoria and Jongoli states to mention a few.

### 3.1.2 General Physiography

The Ethiopian part of the sub-basin comprises high plateaux elevations ranging from 1500 to 2000 m and mountains with peaks exceeding 2,500 meters The elevation decreases towards the Sudan reaching as low as 250m.

### 3.1.3 Climate and Agro-climatic Zones

In the Baro-Akobo area of the sub-basin, the temperature ranges from about $27^0$C below 500 m on the flood plain to 17.5 $^0$C at 2500 m in the high land. The range in mean maximum is 35 to 24 $^0$C and mean minimum from 20 to $10^0$C. The temperature peaks during February and March on the flood plain but high values extend in to April in the high lands. Below about 700m mean maximum values are in excess of $38^0$C for two to three months. There are short periods of more than $40^0$C, the critical value for anthesis of some crops, Notably Maize, but this does not coincide with the cropping season. Daytime temperature in lowlands is very stable over the year with mean maximum not falling below $30^0$C even during the rainy season.

In contrast, land above 2000m is markedly cooler in the area, with mean maximum in the hottest period not exceeding $28^0$C and generally being in the range of 21-$26^0$C. Maximum daytime temperature at this altitude also is stable throughout the year ranging only about $4^0$C. Minimum temperature in the high land seems to be more variable and not so closely related to altitude. The annual mean minimum ranges from $15^0$C at Atnago to $7^0$C at 2320 m at fincha.

The annual mean value of sunshine is about 6 hours daily and shows almost no variation with in the basin. Despite this uniformity, there is considerable seasonal variation. The most sunshine is recorded in the period March to May when skies are clearest and values are mostly 8 to 9 hours daily. The onset of the rainy season produces the dramatic fall in bright sunshine and average values of less than 2 hours daily in august are recorded.

The mean annual rainfall distribution of the sub-basin shows considerable spatial variation due to the complicated nature of the topography. Over the low land areas, the mean annual rainfall is as low as 600 mm and over the high land areas it reaches as high as 3000 mm. (Yeshanew, 1994)

The sub-basin is particularly well-watered region of Ethiopia. Most of the upper sub-basin has an annual total rainfall over 1800 mm. Significant proportion of rain falling during the storms is lost by runoff and the occasional light rain fall out of season when soil and foliage are hot is lost by evaporation; so the effective average rainfall of 750 mm annually in the lowland raising to about 1250 mm in the highland.

The seasonal variation in rainfalls follows the same pattern throughout the sub-basin with a peak precipitation during August. There are striking variation in annual distribution between the north and south of the sub-basin. The more even distribution of rainfall in the south is reflected in the greenness of the vegetation throughout the dry season and contrasts with the parched landscape of the north.

The rainy period of the region is from February to November. The maximum rainfall over the southern portion of the Baro-Akobo river reaches as high as 300 mm in July and over the northern portion of region may reach 250 mm in July. In the northern part of the area, the rainfall amount exceeds 200 mm during June and July.

According to the climatic zones of Ethiopia, Map published by the NMSA in August1989, the sub-basin's portion of Baro-Akobo is characterized by four climatic zones: Aw- Tropical climate II, Am-tropical Climate III, Cwb-Warm temperate Climate I and Xfb- warm temperate climate II.

The temporal rainfall pattern has a single peak in July. Over the sub-basin, average rainfall greater than 100 mm occurs from May to October. Months with average rainfall greater than 200 mm are June, July, August, and September. On average, November, December, January, and February are the dry months over thesub-basin.

The Spatio-temporal mean of the minimum temperature and the maximum temperature for all stations in the Baro-Akobo river area shows that the mean maximum temperature greater than 30$^0$C occurs from February to April, while June and July have minimum temperature values less than 25$^0$c.

### 3.1.4 Land Use/Land Cover

The following table shows the different land cover units of the Baro-Akobo area.

Table 1: Distribution of land cover units of Baro-Akobo area

| DADB | Legend | Hectares | % |
|---|---|---|---|
| BO | Open Woodland | 110,981.94 | 1.46 |
| C1 | Cultivated Area (>60%) | 139,5908.42 | 18.32 |
| C2/FB3 | Cultivated Area (<60%) | 141,391.26 | 1.86 |
| C2/GO | Cultivated Area (<60%) | 154,93.95 | 0.20 |
| C6 | Perennial Crop | 13,899.44 | 0.18 |
| C6/FB3 | Perennial Crop | 25,713.33 | 0.34 |
| C6/FP1 | Perennial Crop | 2,773.07 | 0.04 |
| FB2 | Disturbed Forest | 336,292.17 | 4.41 |
| FB3 | Very Disturbed Forest | 1,085,451.01 | 14.24 |
| FB3/C6 | Perennial Crop | 136,488.10 | 1.79 |
| FB3/GO | Very Disturbed Forest | 10,501.11 | 0.14 |
| FO/WO | Open Woodland | 19,716.41 | 0.26 |
| FR2 | Disturbed Forest | 90,875.98 | 1.19 |
| SF | Perennial Crop | 1861.92 | 0.02 |
| WD | Dense Woodland | 628,296.46 | 8.24 |
| WD/WO | Dense Woodland | 118,404.50 | 1.55 |
| WO | Open Woodland | 3,169,661.54 | 41.59 |
| WO/GO | Open Woodland | 256,885.08 | 3.37 |
| WO/WD | Open Woodland | 60,638.73 | 0.80 |
| Total | | 7,621,234.432 | 100.00 |

*Source: Ministry of Water Resources (Ethiopia)*

### 3.1.5 Livestock

The Baro-Akobo area contains about 1.2 million cattle, 0.4 million Sheep, 0.24 million goats, 0.09 million equines and 1.1 million chickens. Cattle are of primary importance, representing about 90% of the total livestock unit. They are used for draught, milk, capital reserve, and source of cash. Furthermore, they are used for cultural purposes such as status and serve as bride price during marriages.

In the lower sub-basin, the livestock are managed on a migratory system in response to the availability of grazing and water in the plain but the seasonal distribution of the feed is a constraint. In the upper part of Baro-Akobo, feed resources are the main constraints to livestock production.

### 3.1.6 Vegetation/Forest

The Baro-Akobo part of the sub-basin contains about 2.2 million ha of forests. Although isolated into small stands and seriously degraded, they constitute more than half of Ethiopian's remaining forests. Nonetheless, their situation is critical: Loss by exploitation and uncontrolled burning exceed the rate of forest growth. Few primary forests remain: those that remain occur on steep land that is unsuitable even for shifting agriculture.

There are 11 National Priority Forestry Areas: Gerjeda, Sigmo Gaba, Sele Mesengo, Gesha, Yeki, Sheko, Guraferda, Saylem Wangus, Godere, Abobo Gog and Gambela Park.

Based on reconnaissance observations rather than delineating of map units, the forest types delineated include Natural Forest (Afro-Alpine and Sub-Alpine, Coniferous, Aningeria, Olea, Baphia, Evergreen Clump-shade, Mixed Deciduous, Combretum and Acacia, Riparian) and Plantation Forest.

The Afro-Alpine and Sub-Alpine forests lie above 3200 m where they comprise small trees, herbs, and suffrutecents. Little human activity occurs in the zone other than grazing and barley cultivation. Coniferous forest, lying between 1800 and 2500m occur principally on steep lands, where gravity dispersion of seeds assists their regeneration. Aningeria forestes lie between 1600 and 2000 m where the annual rainfall is about 1600-2400 mm. Olea forests lie between 1500 and 200m, their preference for gentle slopes exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species. Bahpia forests often merge with riparian forest and are open forest type. The evergreen clump-shade forests occur throughout the highlands plateau. Remnants of the forest, which once clothed Ethiopian's uplands, are now made-up of island of trees whose under-storey has been removed to provide space for coffee; there is no forest regeneration. The Mixed Deciduous extends along the southwestern edges of the plateau at about 1200m altitudes. The Combretum and Acacia woodlands occupy the low and upper basin between 500 and 1500m altitude. Riparian forest extends through out the plateaux drainage pattern, dropping down to the flood plain. Like the woodland of savannah and upland basin, riparian forests are under enormous pressure from local and refugee population.

Forests are key components of the Baro-Akobo environment. Improved forester provides suitable habitat for many types of wildlife. Dense forest intercepts rainfall and helps protect the soil surface against soil erosion. The resulting betterment of hydrological condition will provide benefits to much of the infrastructure such as roads, dams, bridges, and water supply that lead to improvement to human heath. Advance in the forest economy will offer alternatives to subsistence agriculture, and off-farm income will improve.

### 3.1.7 Biodiversity (Fauna and Flora)

The following are the major environmental concerns and measures identified through the biodiversity assessment made in some of the states found in the Baro- Sobat-White Nile sub-basin in the Sudan (NBSAP, 2002)

#### 3.1.7.1 White Nile State

According to the 1958 classification, White Nile State is divided into two divisions. The first is semi-desert and woodland savannah on clay. It has four subdivisions: *Acacia tortilis/ Mearua crassifolia* desert scrub, semi-desert grassland on clay, and semi-desert grassland on sand and *Acacia mellifera-Commiphora* desert scrub. The second division is the woodland savannah. It has two subdivisions: *Acacia mellifera* thorn and *Acacia Senegal* savannah. From comparison of the historical Harrison and Jackson's classification with the more recent investigations, it can be concluded that annual grasses are still there in their old areas. There are indications of a southern shift in species occurrence. This however awaits further investigation. Available field evidence shows that trees and shrubs have been affected by browsing. Affected species are *Maerua crassifolia*, which has low density and only found scattered. Browsing, over-cutting and drought are the main causes affecting trees density. *Commiphora africana* is one of the most affected tree species in the semi-desert.

Clearance of natural stands for residence and agricultural production, particularly in the southern limits of the White Nile is the main threat. The cut stands are not normally replaced with planting. As a result, the species Dalbergia melanoxylon and Acacia tortilis are endangered. Over grazing especially during the rainy season is the main hazard to plant density. The northern limits of the state are drought-prone as they lie in the semi-desert belt. The second threat is the hazard of fires. Expansion in mechanized rain fed agriculture for food production has been at the expense of the natural ranges. The balance between the numbers of livestock and the grazing has been disrupted. Sand dune fixation in the western part of the state has proved successful.

#### 3.1.7.2 Upper Nile State

The state is endowed with vast plains of relatively stable clay soils, covered by savannah woodland ecological zone. The low rainfall woodland savannah on clay, *Acacia seyal-Balanites* alternating with grassland type covers an area of 17,000 km² along the boundary with Blue Nile State, extending in a narrow belt to river Sobat in the south, extending towards Jelhak and the White Nile. It also occurs in an area of about 7,000 km² round Riangnom. The Upper Nile Swamps ecology surveys and the range ecology survey conducted between 1979-1983 are the latest and most detailed investigation of the Sudd of the Upper Nile. The surveys were funded by EDF funds in connection with the Jonglei Canal project. A total of 350 species of higher plants were identified. The northern Upper Nile area is now open for both legal and illegal charcoal producing activities. According to Khartoum State in 1999, 38 to 50% of the monthly fuelwood supplies to the capital city originate from northern Upper Nile State. Almost all the fuelwood supplies are in the form of charcoal. The bulk is produced in areas already marked for clearance for mechanized rain fed agriculture.

The most adverse effects of the civil war conditions are the cessation of forestry presence and supervision on forestry plantations and installations. The war conditions were also conducive to destructive elements and profiteers to destroy the forestry plantations by unauthorized felling for logs for sale in the north. Forests National Corporation 1999 figures on government plantations, illustrates the extent of damage caused to the plantations of teak, *Tectona grandis*, Sunt, *Acacia nilotica* and other exotic species. The damage caused to teak plantations amounts to 80% of the teak planted area.

### 3.1.8 Wildlife

Gambela National Park of the Baro-Akobo environment in has apparently received legal protection since 1974 and the region was at one time considered as one of the most important wildlife areas. Its present status hardly warrants designations as protected area of any kind. Large area of the original park has been cleared and is being used for cultivation and/or grazing.

High density of wildlife in the south and south west of the sub-basin were reported on 30% of the area sampled from the air. Migration pattern of large mammals were inferred from air photographs; giving a general account of dry season dispersal to the wetter grassland of the west, with rainy season movement to the higher levels of the watershed.

The Baro-Akobo environment was once abundant with wildlife: At least 27 species of large mammals were recorded 25 years ago, atwell (1996), the basin has undergone severe hunting, civil unrest, and depletion of habitat in recent years that resulted in the reduction of its significant mammal population. Important change to the habitat have occurred, most notably the occupation of large part of Gambela National Park by a state farm and Abobo Dam, part of whose upper reservoir also extends in to the Abobo Gog protected area.

### 3.1.9 Fishery

Studies on the fish and fisheries of the Baro-Akobo part of the sub-basin are limited. The Russian Academy of sciences carried out a comprehensive study of the fish species of the lower basin in the late 1980s. This study examined the species composition, tropic status and parasitology of the fish populations but provided no information on the fisheries. No estimates of the number of fisheries operation in the region or an evaluation of their catch are available, and the fisheries department does not, as yet, collect such information. Similarly, in the upper sub-basin, ARDCO-GEOSERV study did not cover the fisheries sector in any detail, and with the exception of an ad hoc fish inventory survey around Ale District by the Russian delegation of the science and technology commission, little information is available from other sources. No formal studies have been carried out in the upper sub-basin region and no assessment of the status of the fisheries has been made.

**Fish Species (>800 m.a.s.l.):** The ad hoc Russian study in the upper catchment around the Ale District found Some 40 fish species out of the 75 identified in the lower Baro-Akobo plain. On the upper plateau, there are Species with a preference for slower flows. As the river descends from the plateau to the lowland plain, it cuts through steep gorges and is fast flowing. In this region, rheophilic (fast water) species such as barbus and Labeo are found.

**Fishing:** In comparison to the Lower catchment, there is little fishing in the upper catchment of the baro-Akobo. Fishing occurs on the Baro, Sor, Weber, Yobi, Dibo and Uka rivers, but is purely on a subsistence basis using traditional methods. The Dominant species caught are Oreochromis niloticus, oreochromis zillii and Barbus species. No data exist on the number of fishermen or intensity of fishing in different parts of the catchment or at different times of the year. The reason for the lack of fishing include: the absence of any suitable size, slow-flowing water or lakes; inaccessibility of major rivers and tributaries for most of the course: and lack of a fishing tradition amongst the local ethnic groups.

**Fisheries Development:** There are some evidences of attempts to increase fish production. The fisheries department of the Ministry of Agriculture in Ethiopia, for example, stocked Lake Bishan Waka Haye near Tepi with 11,000 tilapia fingerlings and Barta reservoir, west of Dembidolo, constructed by the world Lutheran Federation for irrigation purposes, with 58,000 fingerlings. Unfortunately, there has been no follow up of these activities.

**Fish Species (Lower Baro Akobo - <800 m.a.s.l.):** Studies carried out on Species by the Russian academy of Science as part of the overall Russian study (Selkhozpromexport, 1980) found 72 fish species in the lower sub-basin of Baro-Akabo. Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus), Catsish (Clarias sp), Bargrus, barbus and Labeo species were important both in ecological and commercial terms.

Fishing in the region is mainly on a subsistence basis, both in the main river channels and many of the floodplain lakes. Virtually, every family that lives near water fishes to supplement its diet. Active fishing is carried out by men using spears, or modifications thereof, cones, various hook and line devices, traps made of reed, etc.

In addition to the subsistence fishermen, there are three fishing co-operatives at Pinudo (at Tata), Pinkew and Itang which were established by Lutheran World Federation and fish is bought from the co-operatives at 1.5 birr/Kg at Pinudo, 1.25 Birr/Kg at Pinkew and 1 Birr/KG at Itang.

Fishing is highly seasonal in the lower Baro-Akobo sub-basin. Flooding between June and October prevents most fishermen from operating and thus the main fishing season is restricted to the drier periods between October and April.

No direct estimates of present fishing efforts and production are available because catch and effort data are not collected.

### 3.1.10 Water Resources and Wetlands

The major rivers in the Baro-Akobo- sub-basin are Baro and its tributaries (Birbir, Geba, Sore), Gilo with its Tributaries (Gecheb, Bitum, Beg), and Akobo with its tributaries Kashu and Alwero. The general direction of the rivers is from east to west. The rivers rise in the high land (2000-3500m) situated in the east of the area and flow to the Gambela plain (500m) in the west

According to the report on the 43 surveyed wetlands of Ethiopia; Cheffie Gebo, Ginina, Abol, Alwero and Tata (Thata) are located in the Baro-Akobo River Basin described in the following table.

Table 2: Profiles of Wetlands in Baro-Akobo sub basin

| No | Name | Size (ha) | Type | Limnology, Physical features | Use | Threats | Ownership | Management Measures |
|---|---|---|---|---|---|---|---|---|
| 1 | Alwero Reservoir | 2210 | -Man Made | -No rainfall and temperature data<br>-No Limnology Data | -Water Supply, Fishing and Grazing, Forest area | -Deforestation<br>-Malaria and Fascioliasis are Commen | State-Owned | -No known Conservation measures but found in good status |
| 2 | GININA | -Not Delineated | -Seasonal Flood Plain | -Belongs to the wet Kolla agro-ecological Zones near Gambela Town | -Dry season Grazing, Fire- wood collection site, settlement around the wet land | - Mimosa Pigra, an invasive plant becoming a problem by preventing fishing, grazing and farming | State-Owned | -No known Conservation measures |
| 3 | Tata /Thata | 185 | -Fresh water Lake | -Have no Temperature and Rainfall data | -Fishing<br>-Water supply<br>-Grazing<br>-Canoe Transport<br>-Farming | Current<br>-Water hyacinth<br>-Siltation<br>Potential<br>-Introduction of Alien species<br>-Malaria and Fascioliasis | -Annuak People | -Traditional management but facing pressure of refugees |
| 4 | Cheffie Gebo | - No Not Delineated | -Wooded Wetland | -No Limnology Data<br>-No rainfall and temperature data | -Forestry, Pasture, Religious Importance<br>-Water supply<br>- Farming | Current<br>-Farming, Overgrazing and Siltation<br>Potential<br>-Introduction of Alien species, expansion of drainage farming | -Privet Framings<br>- Mechara and Sigsega Farmer Associations | - Management measures to protect trees |
| 5 | Abol | - No Not Delineated | -Seasonal Flood Plain | -No Limnology Data<br>-No rainfall and temperature data | -Fishing (seasonal)<br>-Grazing | Current<br>-No threat<br>Potential<br>-Introduction of Alien species<br>-Malaria and Fascioliasis and tse-tee flies | - Farmers of Abol Kebele farmers | -No management measures<br>- The site is naturally Conserved |

*Source: Environmental Protection Authority*

The source of the White Nile is in the Great or Equatorial Lakes Region, and is also fed by the Bahr-el-Jebel water system to the north and east of the Nile-Congo Rivers divide. Its catchments area includes the riparian states of Tanzania, Rwanda, Burundi, Uganda, Congo/Zaire, Kenya and Sudan.

The Sobat River, which joins the White Nile at just upstream of Malakal, fed mainly by the Baro and Akobo Rivers, flows from the Ethiopian plateau, and is also fed from tributaries inside and outside the Sudan. About 8 md.c.m of its runoff (estimated at 13 md.c.m.) are lost in the *Sudd* area of Sobat and Mashar. Almost all the water flow of Bahr El Ghazal River (estimated at 14 md.c.m.) is lost in the *Sudd* area of Bahr El Ghazal basin, leaving only half a md.c.m. to join the White Nile at Lake No.

The White Nile's flow is tempered by the natural perennial storage of the Great Lakes, of which Lake Victoria is the most important. Consequently, it is characterized by a relatively steady flow pattern. Although the annual water input in the equatorial region can reach 400 billion cubicmeters (bcm), the annual flow at the Sudanese border varies between 20 and 22 bcm because of the lakes' storage. While in southern Sudan, the White Nile meanders for over a year through the Sudd swamp land, where over half of its flow is lost to evaporation. (Fred P., (1994)

### 3.1.11 Irrigation

In Baro-Akobo, ARDCO-GEOSERV identified 18 potential irrigation areas in scattered locations in the upper sub-basin and presented preliminary information on these areas. In contrast, under the Russian study, a comprehensive master plan was developed for the lower basin, which includes several areas located along a band of land above the flood prone zone.

Of those identified by ARDCO-GEOSERV in the upper sub-basin, 17 of the candidate projects were found to be unsuitable for Irrigation.

In contrast with the upper sub-basin, the lower sub-basin, specifically the Gambela plain area mostly above the seasonally flood areas, between elevation 425 and 550 meters above sea level, offer many promising possibilities for the development of irrigation. This was previously reorganized in the study made by TAMS (1970s) and more recently (1995) by Russian master plan. As the result of the latter, the Ethiopian Government decided to undertake the development of 10,400 ha Alwero project that includes the Abobo dam.

In addition, by Baro-Akobo integrated master plan study (1997), 14 basic irrigation systems and 8 variant were identified. The area investigated comprises a gross surface area of about 631,000 hectares. Based on water and land resources, the net area that can ultimately be developed is about 480,000 hectares.

### 3.1.12 National Parks

The lowland area of Baro-Akobo is the site of Gambela National Park. Three controlled hunting areas, Jikau, Alobo, and Tado, are also located in the sub-basin. Despite efforts made to set aside habitat for the preservation of wildlife, the result has not matched expectation and suitable habitat has become compressed. Important constraints are insufficient staff, insufficient awareness, insufficient finance, and absence of plans to manage priority areas, inadequate infrastructure, and no research capacity.

## 3.2 Abbay-Blue Nile Sub-Basin

### 3.2.1 Location and Area

The Abbay-Blue Nile sub-basin covers 311, 482 km$^2$ area in Ethiopia and the Sudan, with an areal coverage of 18.8% of the eastern Nile Basin. The Sub-basin covers 110,763km$^2$ area in Ethiopia, which is about 36% of the total area of the sub-basin. The part in Sudan accounts for 64% of the total area of the sub-basin.
The sub-basin covers parts of Amhara, Benishangul-Gumuz and Oromia states in Ethiopia, and Blue Nile and Sinnar states in the Sudan.

The Abbay sub-basin in Ethiopia occupies an area of 199,812 km$^2$ and is located within the eastern and central part of Ethiopia between latitudes 7$^0$ 45’ to 12$^0$ 45’ N and longitudes 34$^0$ 05’ to 39$^0$ 45’ E. The sub- basin drains towards Sudan on its western border and shares common boundaries with the Tekeze sub basin to the north, the Omo Gibe basin to the south, the Awash basin to the east and southeast and the Baro-Akobo sub basin to the southwest. The basin is located within parts of Amhara, Oromia and Benishangul-Gumuz Regional States.

### 3.2.2 General Physiography

The Abbay River sub basin in Ethiopia has a diverse physiography of various landforms and ranges in elevation from 490 m.a.s.l, where the Abbay crosses the Sudan border, to 4,247 m.a.s.l. in the eastern highlands. The highest mountain is Mt. Guna at 4, 231 m.a.s.l. The upper part of the sub basin is located within the Central Ethiopian Highlands, a vast volcanically formed plateau situated between 2000 to 3000 m.a.s.l. elevations sloping downwards in a westerly direction to the escarpment above the lowland plains and the valley of the Nile River. It contains a mixed topography of high mountains rolling ridges, flat grassland areas and meandering streams that can create spectacular waterfalls where they plunge over the escarpment to the lowland areas.

Lake Tana is the largest lake in the area, located in the northeastern part and is the source of the Abbay River. Other lakes occur within the landscape in extinct volcanic craters. After leaving Lake Tana, Abbay River enters a deep canyon (the Abbay gorge) formed within the underlying Precambrian metamorphic and sedimentary rocks. The gorge directs the river south from its source at Lake Tana and then west to the Sudanese border. During its passage, it progressively increases in depth downstream from Lake Tana to reach depths of up to 1300 m. the canyon forms a natural barrier to communication and together with numerous deeply entrenched tributary water course restricts the extension of groundwater reservoirs and their storage capacity.

The Abbay sub basin has been classified by the FAO (1983) into three general topographic units, which are characterized as follows:

- The plateau highlands: (also called the Central Ethiopia Highlands) the majority of this unit contains elevations between 2000 – 2700 m.a.s.l. Within this unit are inclusions of higher mountains ascending to over 42000 m.a.s.l. This is a vast fertile, volcanically derived plateau and is densely settled. The topography is dominated by volcanic remnants and broken by broad river valleys. Lake Tana, which is an important water resource and wetland area, is located within this unit. The plateau drops steeply to river gorges and the escarpment of the lower plains and hills. This unit dominates the eastern part of the and accounts for about 35 percent of the proper Abbay area;

- The plateau valley in the eastern part, which descends to the Abbay canyon and contains the main tributary rivers of the Abbay River. These include rivers such as the Beshelo, Welaka, Jemma, Muger, Guder, Chemoga and Fettam Rivers. In many places these rivers occupy broad open valleys within the highlands and may then plunge via a series of spectacular waterfalls over the escarpment to the Abbay river gorge; and

- The lower plains and eroded hill lands in the western part of the basin close to the Sudanese border. These contain the outlets to the Didessa, Dabus, and Beles rivers while in the north of the basin the middle and upper catchment of the semi perennial Rahad and Dinder rivers are located within these areas. These areas account for about 40 percent of the Abbay sub basin.

### 3.2.3 Climate and Agro-climatic Zones

The climate in the Abbay River sub basin is dominated by two main factors: the near-equatorial location, between latitude $7^0$ 45’ N and $12^0$ 45’ N, and altitude from 500 m to more than 4200 m above sea level. The influence of these factors determine a rich variety of local climates, ranging from hot and nearly desert along the Sudan border to temperate on the high plateau or even cold on the mountain peaks.

The actual duration of the different seasons depends on the location. This seasonal pattern determines the annual variation of all climatic parameters. A few of them are given below.

- Maximum temperatures are observed in March-April while minima are recorded in July-August;
- The relative humidity get maximum daily sunshine duration from July to September, while minima are usually observed from February to April;
- The maximum daily sunshine duration occurred in December-January, while minima are observed in July-August; and
- Though the variation from station to station is large, the maximum mean wind speed is usually recorded in the period from February to May.

The rainy season (Kiremt) contributes from 50% up to nearly 90% of the annual rainfall.
The small rains season (Belg) is only significant in the extreme east of the basin while it is practically not known around Lake Tana with less than 10% of annual rainfall during this season.

In the area, rainfall varies with two essential parameters: (i) a basic trend of increase with altitude: the low-lying area are generally drier than the high plateau and most mountains are wetter than highlands around them; and (ii) a large interference in this first trend caused by local-and sometimes extensive 'shadow area' effects: the windward sides of the mountains are more subject to high rainfall than the leeward ones, for the dominant wind in each season. A clear case of 'shadow area' effect is the Lake Tana area, where the western side is quite dry (about 800 mm per year at Delgi or Kunzila), while Bahir Dar receives almost twice more rain (1450 mm per year).

Climatic elements of the Abbay sub basin:

- **Rainfall:** mean annual rainfall within the basin varies from 800 – 2000 mm and generally increases with altitude. Rainfall in most of the basin is unimodal with the majority of the rain falling in the wet season (June to September) brought by the southwest monsoon originating from the Atlantic Ocean. The dry season extends from October to march while a period of short rains may sometimes occur from April to May from the penetration of the southeast Indian Ocean monsoon into the basin area. The eastern fringe area of the basin can have a bimodal rainfall distribution, where the 'Belg' rains comprise nearly 50 percent of the 'Keremt' rains. There are two areas of high rainfall (>2000 mm/yr) within the basin. The first is in the headwaters of the Gilgel Abbay, while the second area is south of Bedele in the headwaters of the Didessa River. This area has a longer wet season than the northern area. Rainfall is lowest in the northwest part of the basin where the semi perennial Rahad and Dinder rivers are located.
- **Temperature:** temperature decreases with altitude at a general rate of about $0.7^0$ C per 100 m elevation.
- **Humidity:** increases with decreasing altitude. There is little difference between the stations during the rainy season, when it may reach 88 percent.
- **Wind speed:** varies little throughout the year at either locality.
- **Sunshine:** is slightly lower at lower altitudes and is lower at both stations during the wet season.
- **Evaporation:** figures were unreliable for the basin stations and no figures are available. Potential evapo-tranispairation figures show that evaporation rates are highest in the northwest and eastern parts of the basin.

The combination of these various factors results in very substantial variations in climate. From this analysis and other climatic characteristics, five types of climate can be found for the Abbay sub basin:

*Tropical Climate II:* with dry months in winter, mean temperature of the coldest month above $18^0$ C and a mean annual rainfall between 680 and 1200 mm; this type is prevailing in the north-west, the west and along the deep valleys.

*Tropical Climate III:* with mean temperature of the coldest month above $18^0$ C and a mean annual rainfall between 1200 and 2800 mm; this type is found near Jimma and in a long fringe along the Abbay right bank up to the towns of Debre Zeiyt (Wembera) and Chagni.
*Warm Temperate Climate I:* with dry months in winter, mean temperature of the coldest month below $18^0$ C. more than 4 months with average temperature above $10^0$ C and a relation between mean annual rainfall and mean annual temperature.

*Warm Temperate Climate II:* with no clear dry season, mean temperature of the coldest month below $18^0$ C, the mean rainfall in the driest summer month at least one-third of the mean rainfall in the wettest winter month, the mean rainfall in the driest winter month at least one-tenth of the mean rainfall in the wettest summer month; this type is found in the upper catchments of Didessa and Dabana rivers.

*Cool Highland Climate:* with dry months in winter, mean temperature of the warmest month below $10^0$ C and a mean annual rainfall between 800 and 2000 mm; this type is found around the main mountain peaks: Guna, Choke, Amba Farit and Abuye Meda.

### 3.2.4 Soils

Abbay River Integrated Development Master Plan Project carried out reconnaissance soil survey throughout the sub basin. Accessible areas were surveyed by using 4WD vehicles, while remote areas were accessed using helicopter. The mapping bases used in the reconnaissance field survey were Landsat TM images at a scale of 1:250,000, and topographic map of the same scale. Previous studies were also reviewed and incorporated in the soil analysis of the sub basin.

Table 3: Summary of reconnaissance survey observations

| Data Source | Number of Observations | Area (hectares) |
|---|---|---|
| Reconnaissance primary observation | 910 | |
| Selected (20%) semi-detailed observations | 261 | |
| Observations from previous studies integrated into reconnaissance soil survey | 3,229 | |
| Total observations integrated into reconnaissance soil survey | 4,440 | |
| Basin area | | 19,981,200 |
| Inaccessible areas | | 4,995,300 |
| Leptosols and rocks | | 4,083,626 |
| Marshes and water | | 428,927 |
| Effective basin area | | 10,473,347 |
| Hectares per observation in reconnaissance survey | 2,359 | |
| Hectares per observations in previous studies | 5,010 | |

*Source: Ministry of Water Resources (Ethiopia)*

**Soils classification:** The soils of the basin were classified based on the revised FAO-UNESCO-ISRIC legend to the Soil Map of the world (1988). The FAO-UNESCO-ISRIC legend contains 28 major soil groupings at the highest level and 153 soil units, which are subdivisions of the soil groupings, at the second level. The soil units are further differentiated into soil sub-units on the basis of differential criteria that relate to important soil properties at the third level.

The classification of soils within the basin was carried out based on observable and inferred characteristics of soils based on the field observations and from laboratory analytical data on the physical and chemical characteristics determined.

Soils formed in the eastern part of the basin form the basaltic rock cap are deep, productive, well structured and inherently well-drained agricultural soils. The basaltic derived soils are mostly classified by the FAO system (1988) as Luvisols and are intensively cultivated for peasant agriculture. Those soils formed in the western part of the basin form the underlying strata are somewhat less productive and are classified into a variety of major soils including Nitosols and Vertisols (black cracking clay soils). Other major soils found within the basin include Rendzinas (derived from calcareous deposits) and Lithosols (shallow rocky soils).

Table 4: Major Soil Groups Identified within the Abbay River sub basin

| Major Soil Groupings | Area (km $^2$) | % of Basin Area |
|---|---|---|
| Fluvisols | 799 | 0.4 |
| Regosols | 799 | 0.4 |
| Vertisols | 28,173 | 14.1 |
| Arenosols | 4,596 | 2.3 |
| Cambisols | 17,783 | 8.9 |
| Phaeozems | 1,399 | 0.7 |
| Luvisols | 24,177 | 12.1 |
| Acrisols | 12,988 | 6.5 |
| Nitosols | 71,333 | 35.7 |
| Lithosols | 26,775 | 13.4 |
| Rendzinas | 9,791 | 4.9 |

| | | |
|---|---|---|
| Marshes | 1,199 | 0.6 |
| Total | 199,812 | 100 |

*Source: Ministry of Water Resources (Ethiopia)*

### 3.2.5 Land Use and Land Cover

The various land use and land cover categories found within the Abbay are shown in the table below.

Table 5: Major Land Cover of Abbay sub basin

| Land cover | Total area $km^2$ | Total (%) |
|---|---|---|
| Cultivated | 68150 | 34.1 |
| Tree crops | 260 | 0.1 |
| Plantation | 537 | 0.3 |
| Afro-alpine | 1103 | 0.6 |
| Disturbed forest | 2276 | 1.1 |
| Bamboo | 7326 | 3.7 |
| Woodland, Bush land, Shrub land | 60438 | 30.2 |
| Grassland | 46143 | 23.1 |
| Wetland | 2384 | 1.2 |
| Water body | 3415 | 1.6 |
| Rock | 7932 | 4 |
| Urban areas | 108 | 0.05 |
| Total | 199812 | 100 |

*Source: Ministry of Water Resources (Ethiopia)*

### 3.2.6 Livestock
In the Abbay sub basin, livestock conditions are deteriorating, as more and more traditional grazing areas are being cultivated and the growing livestock population is increasingly being relegated to more marginal lands. Finding feed for the growing livestock population will become ever more difficult and the traditional option of grazing new areas is no longer available.

### 3.2.7 Vegetation/Forest
No areas of undisturbed forests remain within the sub basin. All have been altered by some form of clearing or tree removal (2,276 $km^2$; 1 % of basin). Many of these areas are now occupied for human settlement and agricultural use. Disturbed forest areas remain in Gera, Setena, Jimma, Komto, Chato and Guangua. All of these areas have been classified as National Priority Forest Areas (NPFA's). The standing volume of disturbed forests is in the order of 135 $m^3$/ha and for very disturbed forest; this is reduced to 58 $m^3$/ha.

**Riverine Forests in Blue Nile** Riverine/riverain forests lie along both banks of the Blue Nile as detached areas. They form a very unique forest ecosystem covering a vast area and are of vital economic importance for the economy of Sudan and its nature conservation. They played important environmental and social roles. They provide fuelwood (a major source of rural energy) poles and sawn timber for construction and furniture. They protect the Nile System watershed and soil against wind and water erosion. Riverine Forests are valuable both in terms of their direct use and indirect use values. Examples of indirect use values are the ecological values provided by the forest, which indirectly support economic activities. e.g. prevention of soil erosion, wildlife habitat and microclimate.

*Acacia nilotica* (Sunt) plantations of the Blue Nile flood basins form a significant resource with an area exceeding 13,190.069 feddan (5.7 million hectares). The contribution of *Acacia nilotica* species to the total sawn timber production in northern Sudan is estimated at 40-50%. Its contribution to the production of round timber may be considered as second to the *Eucalyptus.* The latter continues to be the major source of round timber in the Sudan. Sunt also adds a substantial volume to the production of fuel wood estimated at 10-15% of the country's total production (Elasha B.O, 2003).

The composition of the riverine forest changes gradually as one goes southwards. *Hyphaene thebaica* begins to thin out from the riverine forest and the soil progressively shows a finer and higher texture. The southern extreme of this ecosystem is dominated by *Anogeissus leiocarpus* and C. *hartimannianum*. Broad-leafed trees increase towards the Ethiopian borders and these are represented by *C. hartmannianum*, *Terminalia browni*, *Boswellia payriffera* and *Adansonia digitata*.

### 3.2.8 Biodiversity (Fauna and Flora)

In the highland areas of **Abbay**, farming and grazing practices have significantly altered the original flora so that only remnant vegetation now exists in only a few places. There have also been significant introduction of exotic species, which may be both useful to the farmers or they may be present as weeds. In the lower western area, extensive agriculture is practiced and in this area, flora has not been significantly altered like in the highland areas.

A west-east transect of the Abbay sub basin would show a wide range of potential faunal habitats ranging from tropical dry land savanna areas near the Sudanese border to montane vegetation in the eastern part.

**Sennar State:** The natural vegetation cover of the ground flora is composed of mixture of annuals and perennials that decrease in density from south to north, following the amount of rainfall

The vegetation of the state has undergone changes following the advent of rain fed mechanized crop production. Most of the vast plains were deforested for rain fed mechanized agriculture. This situation has lead to the present natural vegetation. Before the introduction of mechanized farming, only *harig* cultivation was practiced. Another threat is illicit felling for domestic or commercial purposes. The remote, inaccessible, and therefore unpatrolled southern parts of the plain are the target for illicit practices. Moreover, the annual reports on the Dinder National Park show continuous decline in the population size of nearly all species.

**Blue Nile State:** The vegetation was classified into three subdivisions within the low rainfall woodland savannah on clay. These are the *Acacia seyal/ Balanistes* woodland savannah on clay alternating tall grasses, *Anogessius leiocarpus/ Combretum hartmanniaum* woodland savannah and the hill catena, which are special areas.

Along the Nile, Dinder and Rahad rivers, the forests of *Acacia nilotica* attain their best development. They occur in seasonally flooded basins “Mayas” along the margin of the Blue Nile and are sometimes found on similarly flooded areas such as drainage channel hollows and old shallow surface catchment depressions. In the extensive mechanized farming areas, which are characteristic of the southeast clay plains, there is no longer any natural vegetation. The lack of clear land use policy is the main constraint to forest conservation in this otherwise very area of natural forests. Forestry as an enterprise has been unable to compete with agricultural production. The three states of the southeast clay plain, Sennar, Gedaref and Blue are traditional cereal granary of Sudan. Mechanized agriculture for the production of food grains and oil seed have started in the Gedaref state in the early 1940s. The enterprise was begun as state farms to feed the Allied Troops in the Middle East during the Second World War. The business was soon privatized and the area was expanded. Production then moved into Sennar and Blue Nile states. At present millions of feddans are annually cultivated.

### 3.2.9 Wildlife

**Abbay sub basin**: There has been severe reduction in wildlife habitats and numbers within the Abbay sub basin due to the conversion of large areas of land for agricultural use. This has particularly affected the more densely populated and human favored higher and cooler altitudes parts of the basin, where few large animal habitats remain intact. However, the lowland areas of the basin are less favoured for human settlement due to the presence of tsetse fly and other climate related human health problems. In these lower western and northwestern areas, some of the large wildlife continues to survive at reasonable population levels

### 3.2.10 Fishery

The Abbay sub basin has limited fish reserves in both lake and riverine systems. Lake Tana with a fisheries potential, remaions the most important fish resource in the sub basin. Apart from Lake

Tana, there is little information on fish species within the sub basin and no systematic fish identification has been done. However, studies have documented two separate fish faunal provinces, which are mainly determined by water temperature. These are (i) the Nilotic lowland fauna and (ii) the Ethioipian Highland fauna.

Table 6: Fish identified within Abbay and tributary rivers

| Family Species | Abbay river | Tributary river | Family Species | Abbay river | Tributary river |
|---|---|---|---|---|---|
| Mormyridae | | | Schilbeidae | | |
| Hyperopisus bebe | X | | Schilbe spp. | X | |
| Mormyrops spp | X | | | | |
| Mormyrus | X | X | | | |
| hasselquistii | X | | | | |
| Mormyrus spp. | | | | | |
| Characidae | | | Mochokidae | | |
| Micralestes spp. | X | | Chiloglanis spp | | X |
| | | | Synodontis spp. | X | |
| Cyprinidae | | | Cichlidae | | |
| Barbus paludinosus | | X | Oreochromis Niloticus | X | |
| Barbus trispilopeura | | | Cichlidae gen spp | | X |
| Barbus intermedius | | X | | | |
| Barbus spp | | X | | | |
| Chelaethiops bibie | X | X | | | |
| Garra spp. | X | X | | | |
| Labeo coubie | X | X | | | |
| Labeo spp. | X | | | | |
| Leptocypris spp. | X | | | | |
| Raiamas spp. | X | | | | |
| Varicorhinus beso | X | X | | | |
| Bagridae | | | Malapterurus Electricus | X | |
| Bagrus spp. | X | | Eutropius niloticus | X | |
| | | | Heterobranchus spp | X | |

*Source JERBE, 1996*

### 3.2.11 Water Resources and Wetlands

The Blue Nile or Abbay is subject to heavy seasonal fluctuations in flow as a result of the seasonal rains of the Ethiopian highlands. Between the months of July and September, flow increases dramatically due to heavy rains, but the river may run empty during dry seasons or droughts.

The contribution of the Blue Nile system from Ethiopian catchment area to the Nile is about twice the contribution of the rivers of the Equatorial Lake Plateau catchment area (White Nile system), but it is characterized by the extreme range in discharges between the peak and low periods, while the flow from the Equatorial Lake Plateau is more uniform At its peak, the former provides nearly 90% of all water reaching Egypt, the latter only 5%. During the months with low flow, the contributions are nearer 30% and 70% respectively.

Within Abbay sub basin, there are two distinctly different hydrological components, namely: (i) The Abbay River and its tributaries and (ii) Lake Tana.

Abbay River sub basin is the second largest basin in Ethiopia after Wabi Shebelle basin, which is in the drier eastern part of the country draining towards Somalia), but has the largest quantity of runoff estimated to be 51 X $10^9$ $m^3$. The Abbay river basin drains to the Sudan through three outlets.

Despite the lack of any basin data, it can be postulated that apart from high sediment loads, the water quality of all rivers that are distant from urban centres, within the sub basin appears to be adequate for most uses (irrigation and livestock and with treatment can be suitable for human use).

Lake Tana with a surface area of 3,042 $km^2$ is the largest freshwater inland lake and an important regulating feature for the Abbay River. The lake is 73 km long and 68 km wide and located at an altitude of 1,786 metres above sea level. Other smaller lakes occur throughout the basin as crater lakes within extinct volcanoes, e.g. Lakes Zengena and Dendi

Lake Tana's water quality appears to be satisfactory and is used as a minor source of supply for Bahir Dar, capital city of Amhara Regional State. The remainder of the town's water supply is being pumped from shallow (5 to 20 m deep) groundwater bores.

Major tributaries of the Abbay River include the following: Didessa, Guder, Angar, Dabus, Jema, Welaka and Wonbera.

In the Abbay sub basin, groundwater is almost exclusively confined to consolidate rocks, which include basalts, limestone and sandstone, and the metamorphic basement rocks. The retention capacity of these rocks is low and any groundwater yield is linked to the occurrence of fracture within these rocks.

There are wetlands in the sub basin. These areas can be either permanent swamps such as the Dabus swamp or, else they may seasonally recede as around Lake Tana. The main wetland areas within the sub basin occur around Lake Tana, the Finchaa, Chomen and the large Dabus swamp. The wetlands have been important bird and wildlife areas and have significance for congregational bird species (Flamingos, cranes, ducks, geese, etc.) and over-wintering areas for a variety of migratory Palaearctic bird life.

Similarly, the Dinder/Rahad wetlands in the Sobat-White Nile sub basin in the Sudan are floodplains occupying areas between Dinder and Rahad rivers, both flowing from Ethiopian highlands; wetlands with an area of 500,000 hectares consisting of flood plain; tributaries with numerous oxbow lakes lie between the rivers and much of the intervening land flooded during rainy season; swampy area around lakes, lagoons, pans, pools and depressions, It forms good grazing sites for wildlife during dry season; home for important migratory and water birds.

### 3.2.12 Irrigation

Large areas of the Abbay sub basin have apparent land suitability for irrigation; however, water availability is seen to be generally a constraint. In the highlands, the highest potential appears to be around Lake Tana, offering supplement irrigation and double cropping potential. In the lowlands, the lower Dabus valley and an area in East Wellega appear to offer the highest immediate potential. However, these comments refer to land potential only; they do not take into account water availability.

Table 7: Irrigation schemes identified in Abbay sub basin

| Name of Project | Selected area (ha) | Cumulated area (ha) |
|---|---|---|
| Seraba | 4,854 | |
| Robit | 5,495 | |
| Guramba | 5,644 | |
| Jarjr | 8,517 | 24,510 |
| Kola Diba | 2576 | |
| Jiwana | 4,735 | 7,311 |
| Bebaha Abo | 2,388 | |
| Gawarna | 1,076 | |
| Fentay | 706 | |
| Delgi | 2,550 | 6,720 |
| Guramba | 1,542 | |
| Mene Guzer | 1,380 | |
| Aba Kiro | 424 | |
| Bebeks | 2,376 | |
| Jigna | 4,199 | |
| Hod Gebeya | 3855 | 13,776 |
| Mitrha | 1,632 | |
| Gubay Mariam | 1,868 | |

| | | |
|---|---|---|
| Kirnya | 842 | |
| Agid/kab | 1,233 | 5,475 |

*Source: Ministry of Water Resources (Ethiopia)*

### 3.2.13 Natural Resources

Table 8: Abbay sub basin – Natural Resources Summary

| **Resources** | **Indicator** | |
|---|---|---|
| Water Resources | River Flows | • Drainage area: 199,812 $km^2$<br>• Average annual discharge at the border: 49.4 BCM<br>▪ 82% from July to October; 4% from February to May<br>• Outlet Lake Tana: 3.5 BCM |
| | Sediments discharge | • 1700 t/ $km^2$/year<br>• 335 Mt/year at the border |
| | Groundwater Flow | • Exclusively included in consolidated rocks<br>• Mean borehole discharge: 3 to 4 l/s<br>• Groundwater recharge: 250 to 300 $m^3$/s |
| Mineral Resources | Non-metallic minerals | • Potential in limestone, marble, gypsum, silica and clay is important |
| | Metallic minerals (sector is limited) | • Gold represents the main potential<br>• Future exploration should be concentrated mainly in the west to investigate occurrences of Cu, Pb, Zn, Cr, Ni, Co |
| Land Resources | Land Suitability in $km^2$ | • Rainfed: 165,680<br>• Smallholder rainfed: 95,150<br>• Mechanised rainfed: 105,280<br>• Irrigated: 58,380 (5,838,000 ha) |
| Vegetation | Land cover % | • Cultivated: 34<br>• Forest+plantation: 1.5<br>• Bambou-woodland: 23.5<br>• Bush: 10<br>• Grassland: 24<br>• Wetland: 3<br>• Rock-urban: 4/100 |
| Soil erosion and conservation | Rate | • At least 100t/ha/yr equivalent to 1 cm/yr from cropland |
| | Slopes (% of basin) | • 0-5%: 47<br>• 5-10%: 14<br>• 10-15%: 3<br>• >15 5: 36<br>100% |
| Energy | Hydropower potential | • 383 kWh (current energy consumption: 140 GWh |
| | Traditional Energy | • 98% of current energy consumption<br>• Mainly fuel wood<br>• 27% sustainable, 73% mining standing stock (annual deforestation rate of 230,000 ha) |
| Fisheries | Potential | • 18,200 tons/year (Lake Tana: 15,000; Fincha reservoir: 750; new reservoirs: 450) |

*Source: Miniostry of Water Resources*

### 3.2.14 National Parks

Despite the existence of large national parks network in Ethiopia, there are no national parks within the Abbay sub basin. The Amhara Regional State has plans to make 9 km$^2$ of national park area at the Tis Issat Falls on the Abbay River, so that the area can be preserved for its scenic value and also for tourism.

However, in the Sudan part of the sub- basin, there is a park known as Dinder National Park. This medium-sized park is in eastern Sudan, on the border with Ethiopia. The park is one of two parks in the Sudan designated as biosphere reserves.

Dinder National Park is bordered by three States: Sennar, Gedarif and the Blue Nile. The Park is bordered by Rahad river at latitude 12$^{o}$26'N and longitude 35$^{o}$ 02'E, and then continues in a northwestern direction up to lat. 12$^{o}$ 42' N and long. 34$^{o}$ 48'E at Dinder River. The boundary continues again up to lat. 12$^{o}$ 32'N and long. 34$^{o}$ 32' E along khor Kennana and finally the boundary slightly diverts to the southeast to lat. 11$^{o}$55'N and long. 34$^{o}$ 44'E Occupies an area of 890,000 ha. The two seasonal rivers, Rahad and Dinder; water the Park during the rainy season. They descend from the Ethiopian highlands and flow in a northwesterly direction across the flat plain to empty their waters into the Blue Nile River. The Dinder River flows through the middle of the Park. It starts to flow around the middle of June. It ceases running in November. The park preserves natural wildlife migration corridor between Sudan and Ethiopia. It is the last remaining wildlife sanctuary in the southeastern clay plains.

The park supports a population of tiang, reedbuck, waterbuck, bushbuck, oribi, roan antelope, warthog, buffalo, greater kudu and red fromted gazelle. These are the major herbivores. Other animals such as baboon and red hussar monkey are frequent. The major predators of the park are lion, striped hyaena, spotted hyaena and the jackal. Many birds are found in the park such as ostrich, marabu stork, clappertoni francolin, cattle egret, crowned crane, grey heron, sacred ibis, hooded vulture, pink backed pelican, bee-eaters, starling and guinea fowl. The annual reports on the park show continuous decline in the population size of nearly all species. There are many population pressures. (HCENR, UNDP, IUCN, 2000). Major sources of impacts is the trespassing by nomads for grazing and firewood, fish bonds poisoning poaching and illegal hunting (World Bank, 2001)

## 3.3 Tekeze-Atbara-Setit Sub-Basin

### 3.3.1 Location and Area

The sub-basin is the smallest sub basin in the Eastern Nile Basin with an area of 219,570 km$^{2,}$ accounting for 13.3% of the total area of Eastern Nile's basin, covering an area of 88, 300 km$^2$ in Ethiopia (about 40% of the total area of the sub-basin) and 133,270 km$^2$ (60%) in the sudan.

Tekeze-Atbala-Setit covers parts of Tigray and Amahara regional States in Ethiopia and parts of kassala, Red sea, Gadaref, Gazira, Nile and Khartoum states in the Sudan.
The Tekeze sub basin, as part of the Tekeze-Atbara-Setit main sub- basin of Eastern Nile, is situated in the northwest of Ethiopia, between latitudes 11$^0$ 40' and 15$^0$ 12' north and longitudes 36$^0$ 30' and 39$^0$ 50'. It is bordered by the Mereb river basin in Eriterea in the north, the Atbara river plains in Sudan in the west, the Abbay river sub basin in the south and the Danakil basin to the east. The size of the area is about 86,510 km $^2$.

The sub basin includes the smaller Angereb (area about 13,327 km $^2$) and Goang (area about 6,694 km $^2$) basins. The Angereb and Goang rivers cross the Sudanese border to the south of the Tekeze and join the Tekeze River downstream in Sudan. Together they form the Atbara River, which is an important tributary to the Nile.

### 3.3.2 General Physiography

The Tekeze sub-basin has an average elevation of 1, 850 m.a.s.l and can be roughly divided into highlands at altitude of more than 1,500 m and lowlands at 500 to 1,500 m above sea level. About 70% of the area lies in the highlands at an altitude of over 1,500 m. The upper reaches of Tekeze are surrounded by mountain ranges, the elevation of which is over 2000m; attaining a maximum altitude (4,620 m) at the mountain of Ancua, part of the Ras Dashen system. The area of land above 2,000 m elevation covers almost 40% of the total sub basin area. The highlands have a mountainous to hilly topography, interspersed with flat to rolling plateaux and plains. Volcanic domes and cones form high-relief mountains in many areas. Plateaux usually terminate in steeply dissected escarpments, where resistant strata have been broken down by geological erosion. Extremely rugged topography exists in major fault zones. The highlands are cut into a number of blocks by the deeply incised gorges of the Tekeze River and its tributaries giving way to flat and rolling lowlands along the Sudanese border to the west.

A very general differentiation, based on physiography and parent material, can be made as follows:

- Highlands on tertiary basalt and tuffs, south of the Tekeze river;
- Highlands on Precambrian and Palaeozoic volcanic, sedimentary and metamorphic rocks, north of the Tekeze river;
- Highlands on Mesozoic sandstone and Createaceous rocks around Mekele and bordering to the highlands with tertiary basalt
- Lowlands with undifferentiated alluvial and colluvial sediments along the Sudanese border.

The following table shows the major landforms of the Tekeze sub basin.

Table 9: Major landforms of the Tekeze sub basin

| Major landform | Area % |
|---|---|
| Level land | 16 |
| Sloping land | 14 |
| Steep land | 52 |
| Composite landforms | 18 |

The Tekeze sub basin as whole is characterized by the dominance of steep land and more than 50 % of the basin has slope gradient of over 30%. The dominant landform in the basin is steep hilly land, with which one third of the basin is covered. Slopping land (gradients 8-30%) covers about 14% and level land (<8%) about 16%. The composite landforms, which combine two or more major landforms, cover 18% of the basin. Really flat land (<2% gradient) occurs in only 5 % of the basin.

### 3.3.3 Climate and Agro-climatic Zones

The Tekeze sub basin can be divided into two regions based on differences in seasons. The region west of the Simien Mountains has two-season type of climate: wet and dry. The wet season in this region lasts for about four months from June to September.

The region east of the Simien Mountains is characterized by three seasons, viz. a dry season from October to February (Bega), a small rainy season that covers the period from mid-February to mid-May (Belg) and the main rainy season that covers the period from June to September (Kiremt).

**3.3.3.1 Precipitation:** Annual precipitation amounts show large variations over the sub basin. Humera in the lowland area has an average precipitation of 600 mm, while locations near the Simien Mountains have annual average of above 1,300 mm. In general, precipitation decreases from south to north from 1,200 mm to 600 mm. However, the Simien Mountains are an exception to this rule, as they experience average annual amounts of precipitation above 1,300 mm.

**3.3.3.2 Temperature:** The temperature is mainly determined by altitude. In the lowland area average annual temperatures are above $26^0$C, while in the Simien Mountains the average temperatures are below $10^0$C. In the largest part of the highlands, the average temperature is around $22^0$C. Minimum monthly temperature occur in the December – February period and range in the basin between 3 and $21^0$C, while maximum mean monthly values occur in March – April and range between 19 and $43^0$C.

Table 10: Thermal Zones in Tekeze sub basin of Ethiopia (after DE Pauw, 1988)

| No. | Traditional name of Zone | Temprature range | Altitude range |
|---|---|---|---|
| T1 | Bereha when dry Lower Kolla | >27.5 | <500 |
| T2 | (Upper) Kolla | 27.5 – 21 | 500 - 1500 |
| T3 | Weyna Dega | 21 – 16 | 1500 - 2300 |

| | | | |
|---|---|---|---|
| T4 | Dega | 16 – 12 | 2300 - 3000 |
| T5 | Wurch | 12 – 7.5 | 3000 - 3700 |
| T6 | High Wurch | <7.5 | >3700 |

*Source: Ministry of Water Resources (Ethiopia)*

**3.3.3.3 Relative Humidity (%):** Minimum mean monthly relative humidity values occur in the dry period (October-March) and can be as low as 40 %. High values occur in the main rainy season (July-August) in which mean monthly values for many stations are above 70%.

**3.3.3.4 Evaporation (mm):** Evaporation is determined by a number of climatic elements. Evaporation occurs from open water surfaces or from plant cover. In the latter case, one speaks of evapo-transpiration. In this report, reference is made to Potential Evapotranspiration (PET), which is the water use of a standard crop experiencing no water shortages. The annual PET varies from 2,200 mm in the lowland (600 m.a.s.l) in the west of the basin to less than 1,000 metres in the Simien Mountains. In the east of the basin, the PET is around 1,600 mm. On an annual basis, however, PET is much higher than the precipitation, except in the Simien Mountains.

**3.3.3.5 Agro-climatic Zones:** Based on the temperature of the area, four basic climatic (thermal) zones can be recognized in the sub basin. They are presented in the table below. The kolla zone is subdivided into three agro climatic zones, the Weyna Dega and the Dega thermal zones each into four and the Wurch into two zones. In this way, 14 agro climatic zones could be created for Tekeze sub basin. The temperature and the dependable length of growing period characterize the 14 zones.

Table 11: Agro-climatic Zones in Tekeze sub basin

| Agro-claimatological zone | Thermal zone | Rainfall (mm/yr) | Potential evapotranspiration (mm/yr) | | Dependable length of growing period | % of basin |
|---|---|---|---|---|---|---|
| K1<br>K2<br>K3 | Kolla | 500<br>800<br>600<br>1100<br>700<br>1500 | 1800<br>1500<br>1500 | 2300<br>1700<br>2200 | 3<br>2.3<br>3.5 | 9<br>6<br>27 |
| WD1<br>WD2<br>WD3<br>WD4 | Weyna Dega | 500<br>800<br>700<br>1100<br>700<br>1000<br>1000<br>1500 | 1500<br>1400<br>1300<br>1400 | 1700<br>1900<br>1700<br>1700 | 2<br>3<br>3<br>3.5<br>3<br>3.5<br>3.5<br>5 | 21<br>8<br>13<br>3 |
| D1<br>D2<br>D3<br>D4 | Dega | 400<br>600<br>500<br>700<br>700<br>1000<br>1000<br>1400 | 1400<br>1400<br>1600<br>1300 | 1500<br>1500<br>1800<br>1700 | 2<br>3<br>2<br>3<br>3<br>3.5<br>3.5<br>5 | 1<br>1<br>5<br>4 |
| W1<br>W2 | Wurch | 700<br>1000<br>800<br>1500 | 1400<br>1000 | 1500<br>1700 | 3<br>3.5<br>3.5<br>5 | 1<br>1 |
| HW | High Wurch | 900<br>1300 | 1000 | 1500 | 3.5<br>5 | 0.1 |

*Source: Ministry of Water Resources (Ethiopia)*

### 3.3.4 Soils

In the Tekeze sub basin, soils with well-developed profiles are rare. Soils developed in moderately deep-to-deep black clays (vertisols and vertic soils) are the main exception, having a fair real extent. Nearly all other soils are shallow, truncated or show very little profile development.

In the basin, particularly the semi-detail surveys conducted at 1:50,000 scale have been related to irrigation development. The areas to be surveyed in semi-detail survey were identified from the regional maps prepared during reconnaissance survey, considering the quantity of water available for irrigation.

### 3.3.5 Livestock

Small-scale mixed farming system is dominant in the whole Tekeze sub basin. It accounts for more than 97% of the farm households. Although the proportion of farmers in the whole basin is low, in the lowlands of the northwest of the basin, there are farmers who own cattle and goats in large numbers and who depend totally on livestock production.

The Tekeze river sub basin cattle are predominantly of zebu type. Five breeds have been identified: Barka (locally called Begait); Arado; Fogera; The Raya-Azebo (locally called Harmo); Abyssinian shorthorned zebu. There are also crossbreeds of Holstein-Friesian and locals used for milk production in peri-urban areas. The proportion of oxen (bulls plus castrates) and cows in the total herd is 27% and 31%, respectively.

The primary feed source in the Tekeze sub basin is natural pasture. Crop aftermath is also extensively used. The farmers in many parts of the Dega and Weyna Dega areas collect crop residues to feed primarily to oxen and lacting cows during the dry period. Opuntia ficus (prickly pear cactus), locally called belese, serves in the eastern and Southern Zones of Tigray both as human food and livestock feed during normal crop seasons and in case of feed deficits. Since it contains about 90% moisture, it is also utilized as source of water for animals during the dry period. The feed supply from all sources declines in quantity, nutritive value and palatability starting from October and remains very low until the rains start.
The total dry matter supply in the basin is 20% above the annual maintenance requirement of the grazing animals. The nutrient requirement in terms of energy and portion components, however, shows a deficit of 31% and 3%, respectively.

### 3.3.6 Vegetation/Forest

With the high rate of increase in both human and animal populations in the Tekeze sub basin, the remaining woodlands and bush lands continue to be under pressure. A number of factors have contributed to this, including population growth which induces increased demand for agricultural land and pasture and causes increased fuel wood harvesting exceeding both the woodland and bush lands regenerative capacity. As a result, most of the vegetation of the basin has disappeared and only little of the original vegetation is evident. It is only the lowland woodland and bush lands in the western and northern part of the sub basin, which are nearer to climax.

From household survey conducted in the highland parts of the basin, 98 % of the farmers indicated that there is a shortage of forest product. This brought a corresponding reduction in the application of dung to enrich the soil organic content. The demand for wood to meet the basic needs exceeds the available supply. The wood supply comes from trees around homestead and farmland, natural woodland and bush lands.

The basin has an acute shortage of industrial wood, which is being imported from other parts of the country. There is no industrial plantation established in the area for current and future consumption.

Woodlands characterize the dominant vegetation cover of the sub basin and bush lands which occur mainly in the agro-pastoral zones along the northern and western part of the basin. They have been heavily used as a source of gum and incense and as sources of fuel wood and fodder for livestock.

The vegetation cover accounts for 1,052,617 hectares. Out of this, the woodland accounts for nearly 77% of the total area of the vegetation thus making woodland vegetation of major land cover.

Table 12: Vegetation Formation of the Tekeze sub basin

| Vegetation Type | Area in ha | Percentage (%) |
|---|---|---|
| Woodland | | |
| Dense bushy woodland | 276,510 | |
| Dense woodland | 245,857 | 77 |
| Open woodland | 288,807 | |
| Total | 811,174 | |
| Bush land | | |
| 1.Dense bush land | 71,230 | 10 |
| 2.Open bush land | 36,293 | |
| Total | 170,523 | |
| Wooded grassland | 133,920 | 13 |
| Total | 1,052,617 | 100 |

*Source: Ministry of Water Resources (Ethiopia)*

The type of forests known to be present include:

- Afro-alpine and sub-afro-alpine heath vegetation
- Broad leaved deciduous woodland
- Acacia bush land

Regarding non-timber forest products, the collection and export of incense has been carried out for centuries. The lowland environment has the best potential for producing naturally obtained gum exudates from Acacia Senegal and incense from Boswellia papyrifera. The Tekeze sub basin is one among the potential areas and has a long tradition of exploiting natural gum and incense. High potential of Acacia Senegal is evident around Humera and Sheraro. Boswellia papyrifera is also dominant in the Welkait and Sheraro Woredas. The central part of the basin is virtually cleared of vegetation cover.

Apiculture or beekeeping is one of the sustainable agricultural sub-sectors which many rural farming communities practise and from which they derive food security and income. Basic biotic resources indispensable for the development of apiculture are honey plants, honeybee colonies, climate and water. As the basin has lost most of its bee keeping potential due to natural and human factors, it falls under moderate and low potential areas. However, some potential areas have been identified in relation to their surplus annual honey production.

The honey yield largely depends on the availability of surplus bee forage, the prevailing weather conditions and type and size of the hives. When conditions are favourable, 2-20 kg of crude honey (honey mixed with beeswax, pollen, dead bees, etc.) has been reported to be harvested from a traditional hive and 12-31 kg from modern hives per annum. The total honey production of the sub basin is estimated at 2,018 tons per annum, which is some 8.2 % of the national honey production.

In the Atbara-Setit sub basin in the Sudan, the woodland savannah on the dark cracking clay alternating with grass areas subdivision is mostly under cultivation. Most of the Butana area, semi-desert grassland on clay soil, is completely without tree or bush**.** The National Capital and the Gezira State in the sub basin are the highest fuelwood consuming areas in the Sudan. Their annual consumption amounts to 2,670,700 and 1,661,870 $m^3$ respectively. This constitutes 32% of the total consumption in the country.

On the other hand, the vegetation of Gedaref state belongs to semi–desert grassland on clay, a subdivision of the semi-desert ecological zone *Acacia mellifera* on dark cracking clay alternating with grass areas; *Acacia seyal/ Balanites* woodland savannah, alternating with tall grass country and *Anogeissus /Combretum hartmannianum* savannah woodland.

In the same sub basin, the semi-desert grassland on clay is the Butana plain, which was once dominated by stands of grasses and frobs such as, *Blepharis edulis, Crotolaria senegalensis, Ipomoea cordofana, Ipomoea spp* and *Ocimum americanum*. Due to over grazing almost more than 50% of the Butana clay plain has lost the valuable forb *Blephairs edulis*. *Cymbopogon nervatus* was and is identified to be on the increase. Over grazing is the main threat to the Butana ranges. Large numbers of livestock normally visit the area during the rainy season. Fire is also a continuous hazard. The northern and central parts of the Butana plain lie in the semi-desert belt and are subject to droughts because of the scanty and erratic rainfall.

### 3.3.7 Wildlife

The Tekeze sub basin has been a focal point of the Ethiopian Wildlife Conservation Organization (EWCO) due to the presence of Simien Mountains National Park. The ecosystem of the Simien Mountains National Park is unique for its scenery, endemicity and genetic importance of the plants and animals that occupy the habitat. Sheraro - Kafta Wildlife Reserve has a substantial potential for wildlife management, as far as the reserve is less utilized by livestock

The basic problem identified is lack of wildlife database for the basin covering such aspects as distribution, status and movement. Such information requires time and manpower. As wildlife, particularly wild animals are under constant change of distribution and status; the gathering of information requires at least two seasons. Without such a database, wildlife management proposals remain somewhat speculative.

### 3.3.8 Fishery

In the Tekeze sub basin, fishery is not well developed. The rugged natures of the landscape together with the seasonal flow of many streams make it difficult to develop this sector in the highlands. In the lowlands, some of the rivers and streams flow all year round and there is potential to increase fish production.

According to the results of the livestock and fisheries survey conducted in the basin and the data gathered at the Bureaus of Agriculture and Rural development in Mekele and Gonder of Ethiopia, the important commercial fish species in Tekeze sub basin are: Oreochromis niloticus, African catfish, Clarias gariepinus, Barbus, Barbus intermedius, other Barbus species, and Bagrus docmac. Other species found in the basin presently have no economic value.

Most people living along the river courses do fish at some time during the year. The small catches of the basin by the fishermen are normally consumed or sold in fresh form. The preservation methods used are sun drying and some times salting. The types of fishing gear that are used in the basin include rod and hook, poisonous plants, cast nets and occasionally small gill nets.

In the upper and mid reaches of the sub basin, occasional and part-time fishermen produce 4–1,000 kg of fish per year (the lower figures are applying to the catches of occasional fishermen). Fish catches with local fishing materials are between 20 and 60 kg/yr. Gill net catches are in order of 1,000 kg/yr. In the lower catches of the river basin, fishing is a part-time and full-time occupation. The fish catches are higher (up to 3,000 kg/yr) than those of the highland fishermen, but still insignificant due to the primitive nature of the fishing gear.

Due to inadequate information on riverine fisheries, the yield potential can only be obtained by extrapolation based on that, a production potential of 40–60 kg/ha/yr can be estimated for the lower reaches of the Tekeze sub basin and about 200 kg/ha/yr for the upper course.

### 3.3.9 Water Resources and Wetlands

The Tekeze sub basin consists of three main influencing areas:

- Tekeze (up to Humera) 63,376 km$^2$ of which 4,070 km$^2$ in Eritrea
- Angereb (up to Abderafi) 13,327 km$^2$
- Goang (up to Metema) 6,694 km$^2$

Drainage in to Sudan 3,113 km$^2$ of which 90 km$^2$ in Eritrea
Total 86,510 km$^2$
Total (without Eritrea) 82,350 km$^2$

Estimated flows at the boundary:

- Tekeze (Humera) 5,875 $Mm^3$
- Angereb (Abderafi) 1,454 $Mm^3$
- Goang (Metema) 862 $Mm^3$

Total 8,191 $Mm^3$

The sub basin contributes an estimated 6.5% of the Nile River flow and the chemical quality of surface water is excellent, both for drinking and irrigation.

Table 13: Main Rivers of Tekeze sub basin

| River Basin | Major River | Major Tributary River |
|---|---|---|
| Tekeze | Tekeze | Zamra, Tserare, Gheba and Worie, Insia and Zarema |
| Angereb | Angereb | Kaza |
| Goang | Goang | Gendua |

*Source: Ministry of Water Resources (Ethiopia)*

Regarding water related resources, with construction of dams and reservoirs (with heights over 15 m), water resources of the sub basin may have a potential for irrigation, drinking water supply and hydropower generation. Less likely purposes in the Tekeze sub basin are fishing, tourism and navigation.

Concerning groundwater resource, an extensive Water Point Inventory (WPI) has been carried out in the basin, during which discharge –draw down data have been collected. Based on of this inventory, it can be stated that the basin has aquifers/formations with very low productivities except high and medium productive areas concentrated around Mekele and Hagere Selam (Agula Shale, Antalo Limestone and Tertiary Dolerite formation).

The WPI included 720 water points, out of an estimated 1,000. It is assumed that an average of 2.69 l/sec is extracted from each well during 8 hours per day; then the total extraction per year is 28 $Mm^3$, a fraction of the total annual recharge from rainfall, estimated to be at least 2,500 $Mm^3$. if a safe extraction factor of 15% is adopted, 375 $mm^3$ can be extracted in the basin annually.

The quality of ground water is usually better than surface water. Groundwater is to be found everywhere in the sub basin, but the art of locating a productive well site is to strike a groundwater bearing and conveying fracture system. Results of the water point inventory indicate that most wells (77 %) have only one water entry (fault or fracture) in the borehole from where water is pumped. Such entries are not easy to find. Exceptions are the limestones near Mekele, which have a well-developed system of fissures (dissolved pathways). The quality of this water is not very good. Other good locations are areas near large (dry) riverbeds (bank infiltration). If no groundwater can be found, surface water runoff is the only alternative

The hydropower potential of the Tekeze sub basin is quite large. Rivers are quite steep and some have deep gorges, which make ideal dam sites. However, high dams and large reservoirs are required to produce sufficient firm power. The total potentially generated firm energy of the basin is 4117 GWh/yr.

In 1995, water demand in urban areas was estimated at 35 lcd and in rural areas at 20 lcd. With the improvement of the water supply infrastructure, these figures have been estimated in the year 2030 to increase to 60 lcd in urban and30 lcd in rural areas. Total demand in 1995 is 37 $Mm^3$ (1.2 $m^3/s$) and in 2030 173 $Mm^3$ (5.5 $m^3/s$), figures that are small compared to the total outflow of the basin of 8,191 $Mm^3$ (260 $m^3/s$) also when an estimated 30% for non-domestic uses is added.

### 3.3.10 Irrigation

In the Tekeze sub basin, large-scale irrigation potential created by impounding water in large dam in the lower reaches of the river has been calculated on the bases of data on mean annual regulated flow from reservoirs in the Tekeze, Angereb and Goang/Gendua rivers.

| | | |
|---|---|---|
| ▪ | Tekeze | 152,700 ha |
| ▪ | Angereb | 23,200 ha |
| ▪ | Goang/Gendua | 13,600 ha |
| | Total | 189,500 ha |

The major part, 82% of the basin, is not suitable for irrigation. In the first place, because of a too high slope gradient (s), this is the most limiting factor for this land use, accounting for 73% of the basin. The other problems are the rooting conditions, which are limiting for crop growth and for drainage of the irrigated lands. This limitation accounts for 68% of the basin.

About 5% of the Tekeze sub basin is highly suitable for irrigated agriculture. Most of the suitable areas are found in the western lowlands, but also they occur around Shiraro and Arbaya. Moderately and marginally suitable lands cover 12% of the sub basin. It should be mentioned here that the availability of water is not taken into account. These moderate and marginally suitable lands can be found in the western lowlands, east of Adi Ramets, near Shiraro and north of Mekele. If water is available, some small-scale irrigated agriculture can be practised in these regions.

The Tekeze sub basin has the potential to expand and develop irrigated agriculture. Small-scale schemes are appropriate for peasant farming, medium-and large-scale schemes for (commercial) agricultural undertakings and enterprising settlers. Large investment and high level of technical knowledge will be important inputs. Traditional irrigation needs to be expanded and supported to play its role in crop production.

If enough sites for micro-dams in the upper and middle catchments can be found; 1,500 dams each storing one million $m^3$ have been foreseen. These can provide supplementary irrigation on a small-scale basis to 450,000 ha of cropland in the wet season and to 112,500 ha in the dry season. The reconnaissance soil survey cannot confirm whether suitable land in such amounts is available. However, estimate of the SAERT and SAERAR projects indicate that the above figures are not out of range of reality.

Table 14: On-going small-scale irrigation development schemes in Tigray Region of Ethiopia

| Zone | District | Scheme | Ha | Stage | Responsibility |
|---|---|---|---|---|---|
| South | Adi Gudom<br>Kuiha | Gum 30<br>Arato | 100<br>100 | Construction | SAERT<br>SAERT |
| East | Wonberta<br>Agula | Era<br>Wukro | 100<br>100 | Construction | SAERT |
| Central | Lailay<br>Maychew<br>Tembien<br>Worie-leke<br>Abergelle | Mai Neguse<br><br>Adha<br>Seguha<br>Agbe | 100<br><br>100<br>30<br>30 | Construction<br><br>Operational<br>Construction | SAERT<br><br>REST<br>REST |
| West | Adi daero | Enda Mariam | 30 | Construction | SAERT |

*Source: Agronomy survey 1995*

Table 15: On-going small-scale irrigation development schemes in Amhara Region of Ethiopia

| Zone | District | Scheme | Ha | Stage | Responsibility |
|---|---|---|---|---|---|
| Wag Hemra | Sekota | May Lomi<br>Mahabere Genet | 50<br>60 | Construction | SAERT<br>SAERT |
| North Gonder | Belesa | Zana<br>Atelkaina | 65<br>50 | Feasibility | SAERT |

*Source: Agronomy survey 1995*

Regarding large-scale irrigation, three projects have been proposed:

- Humera, with a gross (net) irrigable area of 50,500 (42,965) ha;
- Angereb, with a gross (net) irrigable area of 13,592 (11,561) ha;
- Metema, with a gross (net) irrigable area of 19,276 (16,385) ha

Priority crops for irrigation are potato, lentil, bean, onion and vegetables in the highlands; chickpea, vegetables and fruit trees in mid-altitudes; sesame, cotton, groundnut, sugar cane and vegetables in the lowlands. Cereals as barley, wheat, maize and sorghum may be grown, preferably under supplementary irrigation, but they may not give large enough returns to be economical.

Currently, irrigated agriculture in the sub basin has not yet been developed. The existing practice is entirely dependent on traditional irrigation (diversion and spate) systems, which have both limited area coverage and low yield levels.

The existing irrigation practices are dominated by traditional and inefficient practices and both area coverage and productivity are at low levels. The current area coverage is not more than 10,000 ha; as virtually no external inputs and improved water management practices are adopted by the farmers. Recently, encouraging efforts on irrigation development have been made in both regions. However, due to inadequate planning and inefficient implementation, irrigation has hardly been started even in several completed irrigation schemes.

### 2.3.11 Mineral Resources

In the Tekeze sub basin, placer gold is being recovered from numerous small panning sites. It is estimated that several hundred kilograms of gold are recovered annually using this labour intensive method. Resources of gold, which could be exploited by mechanized mining very probably, exist; exploration is needed to indicate which of the known gold occurrences could be profitably mined. Marble and limestone are being quarried from localities south of Adwa and north of Mekele

### 3.3.12 Tourism

The main international tourist attraction in Ethiopia is in the Tekeze sub basin, which is the so-called historic route, a circuit that includes Lake Tana and Gonder (Just outside the basin), lalibela, Mekele and Axsum. This is the best-known and most visited part of Ethiopia by international tourists. The Simien Mountain National Park is another major asset in the sub basin, too.

## 3.4 Main Nile Sub-Basin

### 3.4.1 Location and Area

The sub-basin covers 656,398 $km^2$ or about 40% of the total area of Eastern Nile Basin. It is the largest sub-basin in Eastern Nile and covers 586,398 $km^2$ in the Sudan and 69,722 $km^2$ in Egypt accounting for 89% and 11% of the total area of the sub-basin in the two countries respectively. The Main Nile extends from about $15^0$N in Central Sudan to $32^o$N in the Mediterranean coast of Egypt.

The states fully and partially covered by this sub-basin in the Sudan include kassala, Khartoum North Darfur, North Kardafan, West kordofan Gadarif and Northern States, while Aswan, Red Sea and New Valley are states covered in Egypt.

### 3.4.2 Climate

The climate of the Main Nile sub basin in both Sudan and Egypt belongs to arid-desertic to semi-desertic conditions. It is characterised by long hot rainless summer and short rainy mild winter with scarce rainfall. The other seasons are also characterized by unstable climate.

#### 3.4.2.1 Temperature

The maximum air temperature is affected by the geographical location of both Sudan and Egypt north of the Equator. It increases generally from north to south. The temperature gradient varies from month to month, where the difference between the maximum temperatures from north to south reaches 15°C in May and June, and 5°C in January. The maximum air temperature reaches its highest value in the south during June, while August is the hottest month in the northern coast.

The minimum air temperature around the sub basin's part in Egypt occurs during January. The water surfaces and the highlands complicate such distribution, since the temperature gradient is well defined near the coasts of the Mediterranean and Red Sea during spring and summer seasons and turns to be weak during autumn and winter Seasons. This is due to the relatively low sea surface temperature during the first period and relatively high during the second one.

#### 3.4.2.2 Relative Humidity

Since the humidity distribution depends upon the nature of underlying surface, topography, distance from sea, and dominant synoptic situations, it is found that the highest R.H. exists over northern coast of the country. During summer, reaching more than 70% and decreasing inwards to reach 20% far to the south with appreciable gradient at the north and weak gradient at the south.
Moreover, a steep R.H. gradient is evident near the Red Sea coast, which weakens westwards. While over Sinai, the humidity gradient is strong near the coasts circumventing low R.H. region (30%) over southern mountains. In autumn, the values of R.H. are greater than 70% in Nile Delta and the eastern coasts of the Mediterranean, while it is less than 70% over the eastern coasts and reaches 30% in the south. During winter, the humidity is still high in both east and south leading to well-defined decrease in the gradient than that observed over both northern coasts and Sinai. This feature is reversed during spring thus; humidity starts to decrease southwards resulting in gradient greater than the winter gradient to approach the characteristics of the summer distribution.

#### 3.4.2.3 Precipitation

Precipitation in the Main Nile sub basin in Egypt is usually associated with unstable weather conditions due to the invasion of cold air masses in the upper atmosphere and low-pressure troughs in the lower atmosphere. The rainy season in extends from autumn to spring. Maximum precipitation occurs during winter due to the passage of the Mediterranean depressions. The north east of Delta is distinguished by highest amount of precipitation due to the characteristics of the topography where the prevailing air stream is mainly perpendicular to the coast. However, the north coast is distinguished by maximum precipitation, which decreases rapidly inland to Middle part becoming too rare in Upper and Western part.

#### 3.4.2.4 Atmospheric Pressure

The atmospheric pressure over Egypt, during different seasons is influenced by four synoptic systems, namely: Sudan low, subtropical anticyclone, Indian monsoon low and Mediterranean traveling depressions.

During spring and autumn, the pressure distributions are more or less similar where eastern and southern Egypt are influenced by Sudan low with the subtropical high pressure dominating over north-western region with greater intensity during autumn than during spring.

In winter, both the Sudan low and subtropical anticyclone advance southwards and the Mediterranean travelling depressions frequently invade northern region causing thunderstorms and showery conditions.

The effect of Indian monsoon low is much pronounced over north and east of Egypt during summer where the subtropical anticyclone or its ridge affects western and southern region.

It is a normal practice that surface air temperature over Egypt depends upon the eastwards or westwards movement of such pressure system. Thus, heat waves occur when the Indian monsoon low extends westwards, while these circumstances cease when this pressure system retreats to east giving opportunity for the subtropical to dominate over the whole region.

### 3.4.3 Wetlands and Water Resources in the Main Nile Sub basin in Egypt

#### 3.4.3.1.Wetlands

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al, 1979).

Wetlands in the Main Nile sub basin are classified into two broad categories: coastal and inland wetlands. The major problem of coastal wetlands in the northern part of Nile Delta is the intrusion of saline water into fresh water aquifer. Depressions of western desert or other areas along the Nile valley can be further classified as either natural wetlands (Wadi el Natrun depression), or manmade wetlands (Siwa oasis).

### 3.4.3.2 Major Watershed

Watershed is located in northeast coast and in the north Sinai of Egypt. The average annual rainfall over the north western coast region, port said, El-Arish, and Rafah is about 150 mm, 80 mm,113 mm and 313 mm respectively. Recently, dikes have been erected in many places to help in water harvesting and minimize water loss.

### 2.4.3.3 Lakes

The Main Nile has two main branches, and many man-made distribution canals and drains that collect drainage water from irrigated lands. These drains dump their water into four ancient depressions, forming lakes along the Delta coast. These four lakes (Manzala, Burullus, Edku, and Mariut) represent a vital economic resource in Egypt, due to their shallow depths and huge quantities of nutrient-rich water disposed from agriculture drainage. They produced 152,095 tons of fish harvest in 1998, which represents 28% of the total fish production in this year.

**Lake Manzala**

Lake Manzala is the largest northern lake. It is situated in the northeast corner of the Nile Delta, and falling in the jurisdiction of five governorates. It is separated from the Mediterranean Sea by a sandy beach ridge, which has three open connections (bugaz) between the lake and the sea. The surface area of the lake is 280,000 feddans. Lake Manzala has the largest fishery production (78,261 tons in 1998) compared to the other northern lakes. The fish species of the lake have been changed, which previously were characterized as marine fish.

After the construction of Aswan High Dam (AHD), the mullet –based brackish water fishery has been replaced by tilapia–based fisheries due to the constant inflow of freshwater with high nutrient concentration. Tilapia represented about 51% of the lake fishery, while mullet represented about 3.6% of the total harvest.

The gradual reduction in fish biodiversity is attributed to the decrease in overall salinity. Additionally, water pollution and excessive eutrophication in the southeast region is the major indicator limiting the species inhabiting this region to the tolerant ones.

**Lake Burullus**

Burullus Lake is situated along the Mediterranean coast and occupies a more or less central position between the two branches of River Nile. The lake is oval in shape with estimated area of about 114,520 feddans. It is a shallow basin with variable depth ranging between 0.6 and 1.6 meters.

The lake has about 70 islands, of which 55 are artificially created by filling reed-infested area with soil. Burullus Lake receives its water from different sources:

- Sea water, through natural inlet at it's northeast border;
- Brackish water dumping from agricultural reclaimed areas and drains; and
- Brackish-salty water, through the bramble Manila on the wet coast.

After the closure of AHD, margins of the lake were made to develop for land reclamation for agriculture expansion. Eight drains were constructed to leach the soil salinity into the southern shore of the lake. Burullus Lake is considered one of the highly productive lakes in the Mediterranean with about 31% of the delta lake's area. Burullus Lake produced 59,033 tons, representing about 42% of all delta lakes. It has the most productive mullet fishery of the delta lakes due to wide lake- sea connection, which allows high recruitment of mullet fry from the sea each year.

During 1960s and 1970s, the lake produced the highest percentage of mullet out of the total mullet catch. However, starting from 1980s, there has been a limitation in water exchange through the connection with the sea, which resulted in reducing marine water zones in the lake. In 1998, Tilapia presented 60.4% in lake catch (35,700 tons), while mullets and other marine species presented 20.1% (11,885 tons). The fishery of sea had gradually decreased in 1991, and completely disappeared in 1999. This indicates that the environmental changes in the lake are in favor of species preferring water with lower salt content.

### Edku Lake

It is the smallest northern delta lakes. It is located about 30 km to the Northeast of Alexandria. The lake area reaches about 27,470 feddans. Edku lake is the third fishery productive among delta lakes (10,280 tons in 2001). The source of lake water is coming from two agricultural drains. Bersik drain enters the lake from the southern edge and Edku drain enters from eastern side of the lake. Exchange of water between the northern side of the lake and the sea is insured through a narrow slit 'Boughaz El-Maadia'. The area of the lake is divided into three basins due to emergence of a number of islets.

The salinity of Edku lake varies locally and seasonally. It fluctuates from less than 0.09 % in the eastern basin to about 1.4 % at El-Maadia region inside the Boughaz. Edku lake contributes 7% of the overall production of northern lakes (10,300 tons), of which 90% Tilapia and only 5% mullet.

### Lake Mariut

Mariut Lake is situated southwest of Alexandria along the Mediterranean coast. The area of the lake is 15,000 feddans. Mariut Lake receives a water blend of agricultural, domestic sewage and industrial wastes from several anthropogenic sources. The main inflows are through Nubaria canal, and various large drainage channels serving the rich agricultural area of the Nile delta. The other sources are the Umum Drain (agricultural rain), Qalaa drain (mixed wastewater), rainfall, and Alexandria urban and industrial wastewater beside seepage of groundwater from the surrounding area.

AHD stopped the annual autumn flooding of the Nile into the lake, although Nile water still enters the lake in a more controlled manner through the Nubaria Canal. The loss of silt deposition by the Nile in the delta has lead to increased fertilizer use to maintain soil fertility. This process has raised the opportunity to greater nutrient inputs to the lake via drains.

Fishery statistics show that Mariut Lake was the most productive (14,000 tons per year) lake during 1974-1977 compared to the other northern lakes. Since 1980s, its productivity began to decrease from 14100 tons in 1980 to 5,500 tons in 1985, reaching below 2,000 tons in 1990, and then remained in the average of 3,500 to 4,506 tons. Mariut Lake has no connection with the sea; so no marine fish were found in catch in 1998. Tilapia and catfish contributed 72%and 27% of the harvest, while Eels and grass carp 1% and mullets 0.02%.

### Qarun Lake

Qarun lake is an inland closed basin of 23,000 ha, and an average depth of 8 m. In the ancient times, Qarun Lake was connected with river Nile forming a natural reservoir of freshwater, which supplied Fayoum depression with floodwater of the Nile. Whenever the lake became disconnected from the river Nile, its water level lowered and its surface shrunk due to evaporation, until a new flood raised its level and size again. Consequently, salinity has been steadily increasing.

The mean salinity had increased from about 11 ppt in 1906 to about 34 ppt in 1982, and at present, the average salinity reaches 39 ppt. It is estimated that 589,000 tons of salt enters the lake annually. If the level of salinity continues to increase, it may reach 50 ppt by the year 2020 transforming the lake into a dead sea. The only source of water supplying the lake is the agricultural drains (especially wadi and Bats drains).

With the increase in salinity, the fish funa changed; freshwater species disappeared, and were replaced by introduced species from the Mediterranean: mullets, sole, and shrimps. The annual maximum sustainable yield (MSY) for nutrient-rich marine enclosure would be in the order of 75 kg/ha, or, for the whole lake, some 1,700 tons. This yield was reached in the seventies, but thereafter it decreased to 1,500 tons in the late eighties and to around 1,000 tons now (40% tilapia species,20% mullets,10% sole, and 10%shrimps). This decrease is partly due to hypersalinity in some areas. There were several stocking programs to the lake started in 1929 with mullets, in 1938 with soles, in 1970 with sea bream, sparus aurata, sea bass, dicentrachus labrax and eels, Anguilla species were introduced and prawns' species was transplanted to the lake in 1977.

The harvest composition has changed due to the high salinity level of the lake. Glancing at the 2002 harvest, green tilapia (tilapia Zillii) represents about 49 % of the catch, mullet 27,5%, soles 16,3 % and shrimp 6%.

**Wadi Al-Rayaan Depressions**

In mid seventies, the yearly increasing volumes of drainage water of the Fayoum depressions threatened to raise the level of Qarun lake beyond acceptable levels. Therefore, a tunnel was constructed to spill excess drainage water to Wadi El Rayaan depressions, resulting in two lakes (Rayan I and Rayan III), connected by a connection waterway. The connection is called Rayan II.. The total area of the lakes amounts to 18,000 ha.

Fishing activities have started in 1983. The present production is in the order of 1,073 ton (of which tilapia 42.9%, mullet 29.5%, Nile perch 14.2 %, and carp 7.2%). With no precipitation and a very high evaporation rate, a rapid increase in salinity takes place. For the dominant fish species small further rises in salinity are ineffective; the production will move towards more tilapia and a larger share of mullets.

### 3.4.4 Ecological Zone and Forest in Main Nile Sub basin in Egypt

Egypt, with land extending about one million square kilometers under arid and hyper arid climatic conditions, is endowed with varied agro-ecological zones with specific attributes of resource base, climatic features, terrain and geomorphic characteristics, land use patterns and socio-economic implications. The zones could be identified as follows:

- **North Coastal Belts:** including North West coastal areas and Northern areas of Sinai;
- **The Nile Valley:** encompassing the fertile alluvial land of Upper Egypt, the Delta and the reclaimed desert areas in the fringes of the old valley;
- **The Oases and Southern Remote Desert Areas:** including East Owaynat, Toushki, and Darb El Arbien Areas and Oases of the old Nile valley;
- **The Desert Inland:** including the plateau and dry valleys of Sinai and elevated areas in the South Eastern Desert

Table 16: Agro-ecological zones and their locations

| Agro-ecological zone | Altitude | Major land forms/ physiographic units | Major soil types | Dominat land use farming zone |
|---|---|---|---|---|
| Nile Delta | 0-50m | -The young deltaic plain<br><br>-The Mediterranean coastal plain | -Flood plain<br>-Aeolian deposits<br>-Fluviomarine<br>-Lagoonal deposits<br>-Beach deposits<br>-Coastal Aeolian deposits | Crop pattern and rotation includes: Field crops, vegetables and fruit crops |
| Nile Valley | 20-50m | -Rubble terraces<br>-River terraces, (west)<br><br>-Kom Ombo.<br>-Wadi Botloms<br>-Outwash plains<br>-Alluvial fans (East Kom Ombo) | -Gravelly sand soils<br>-Alluvial soils<br>-Sandy to gravelly sand soils<br>-S. to Gr.S.Soils<br>-S.to Gr. S.Soils | Areas under reclamation in Middle and upper Egypt |

#### 3.4.4.1 Man-made Forests and Programme Implementation Sites

This is to be achieved by establishing forest plantations, i.e. man-made forests. Most of the man-made forests in Egypt are irrigated by treated sewage water, resulting in the production of trees with high quality timber.

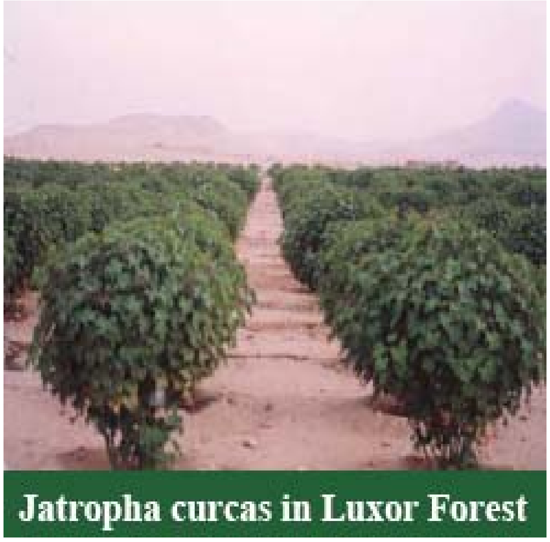




Fig 1: Program Implementation Sites in Egypt

In addition, Egypt has developed, and is currently implementing, a strategy for combating desertification. This includes the establishment of nurseries for the afforestation of new roads, the improvement of existing plantings along roads, and the stabilization of sand dunes through tree planting.

The main objectives of this National Program or NAP are as follows:

- Solve the problem of 2.4 billion cubic meter of accumulated wastewater; disposal of such quantity represents a major environmental problem;
- Benefiting from this huge water quantity and not squandering a water resource that could be exploited economically;
- Limiting the discharge of wastewater into the River Nile or in seas in order to prevent bacteriological and chemical pollution of water (from heavy elements and harmful organic compounds), and the degradation of fish wealth, river and marine bio-ecological systems. Discharging into open desert also pollutes both surface and deep underground reservoirs;

- Preventing adverse practices related to the use of untreated wastewater in producing agriculture and food products;
- Contributing to the provision of health benefits to individuals as a result of
- Eradicating reproduction sources of insects and disease vectors caused by the accumulation of stale wastewater;
- Transforming an area of 400,000 feddans from desert into ecologically rich areas in terms of:
    - Preserving the soil;
    - Enriching natural and biological components in arid and semi-arid areas;
    - Forming attraction and development zones for potential inhabitants of these areas;
    - Adding productive desert lands to the agricultural environmental system.

- Participating in cleaning air pollutants, adding climate soothing factors in arid and semi-arid areas mostly adjacent to desert boundaries, and protecting cities and housing areas from sand dispersion and dust storms; and
- Participating in restoring the equilibrium of the biosphere components through increasing oxygen quantity and absorbing quantities of carbon dioxide.

**Programme Implementation Sites:** This program is implemented in areas surrounding wastewater stations in the different Egyptian governorates with a desert backlog as indicated in

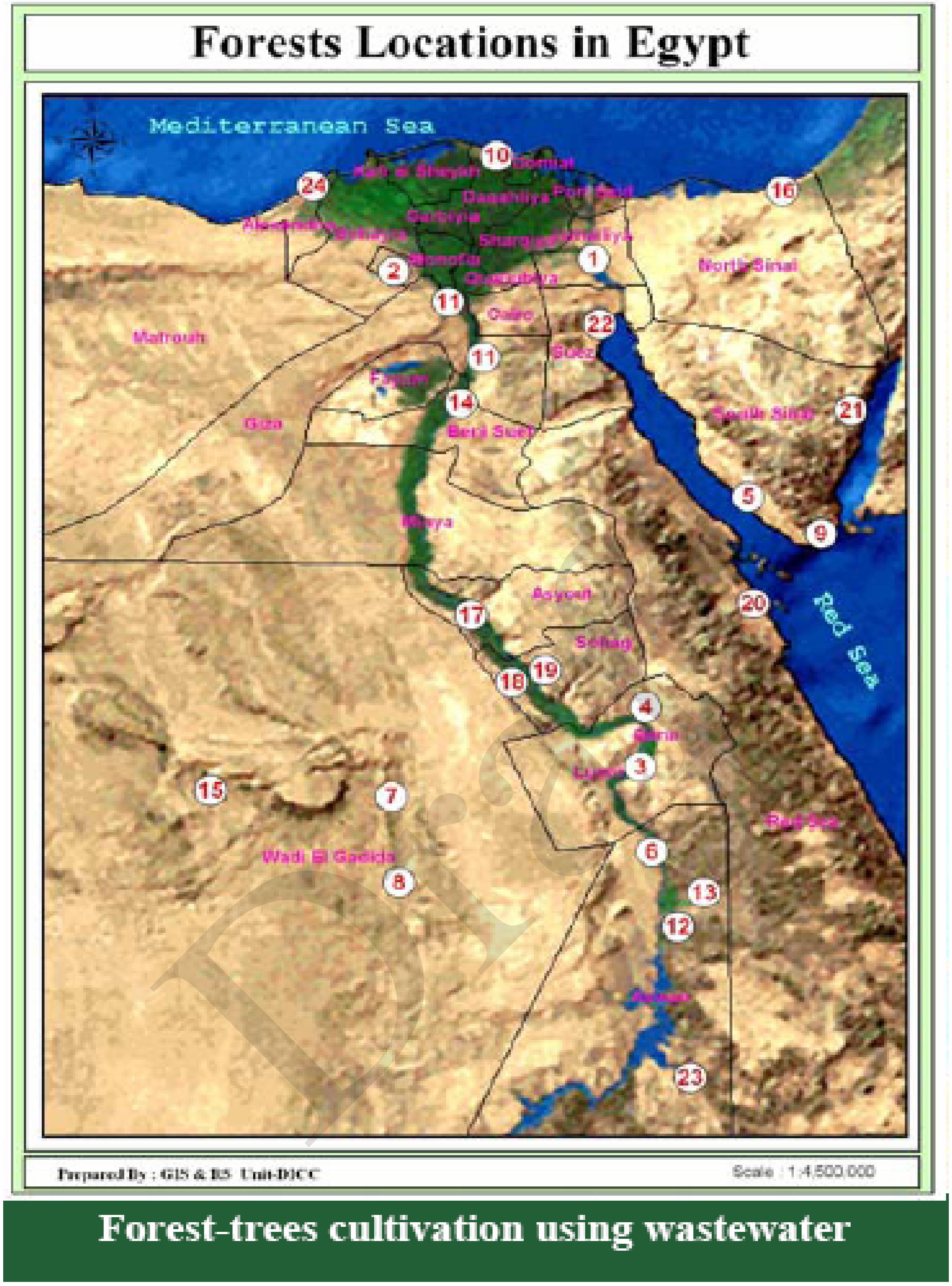



Fig. 2 Forest locations in Egypt

Table 17: List of established afforestation areas irrigated by treated sewage in Egypt

| Sr. | Governorate | Forest | Area (Feddan) | Plant Discharge Capacity ($m^3$)/day | Irrigation System | Cultivated Plant Varieties |
|---|---|---|---|---|---|---|
| 1 | Ismailia | Sarabioum | 1000 | 90000 | Drip irrigation | Cupressus sp. – Pinus sp. – Khaya senegalensis – Casuarina sp. – Eucalyptus sp. – Morus sp. – Concarpus sp. – Agava sisalana – Dendrocalamus strictus |
| 2 | Mounefia | El Sadat* | 500 | 18000 | Drip irrigation | Cupressus sp. – Pinus sp. – Acacia saligna – Casuarina sp. – Eucalyptus sp. – Agava sisalana – Morus sp. – Khaya senegalensis – Ornamental trees and plants |
| 3 | Luxor | Luxor | 1700 | 30000 | Modified Flood and Drip Irrigation | Khaya senegalensis – Eucalyptus sp. – Acacia saligna – Morus sp. – Jatropha curcas |
| 4 | Kena | Kena | 500 | 23000 | Modified Flood Irrigation | Eucalyptus sp. – Khaya senegalensis |
| 5 | South Sinai | Tur Sinai | 200 | 3500 | Modified Flood and Drip Irrigation | Casuarinas sp. – Eucalyptus sp. – Morus sp. – Popular sp. |
| 6 | Aswan | Edfu | 300 | 8000 | Modified Flood Irrigation | Khaya senegalensis |
| 7 | New Valley | El Kharja | 400 | 13000 | Modified Flood Irrigation | Khaya senegalensis – Casuarina sp. – Eucalyptus sp. – Terminalia sp. – Tamarix sp. |
| 8 | New Valley | Paris | 200 | 18000 | Drip Irrigation | Cupressus sp. – Pinus sp. – Acacia saligna – Casuarina sp. – Eucalyptus sp. |
| 9 | Giza | El Saf | 500 | 65000 | Drip Irrigation | Khaya senegalensis – Casuarina sp. |
| 10 | Dakahleya | Gamasa | 150 | 1500 | Drip Irrigation | Cupressus sp. – Pinus sp. |
| 11 | South Sinai | Sharm El Sheikh | 60 | 3000 | Drip Irrigation | Casuarina sp. – Eucalyptus sp. – Ornamental trees and plants |
| | Total | | 5510 | | | |

* Egyptian-Chinese Friendship Forest

Table 18: List of under establishment afforestation areas irrigated by treated sewage in Egypt

| Sr. | Gover-norate | Forest | Area (Feddan) | Plant Discharge Capacity ($m^3$/Day) | Irrigation System | Cultivated Plant Varieties |
|---|---|---|---|---|---|---|
| 12 | Aswan | Aswan | 500 | 8000 | Drip Irrigation | Khaya senegalensis – Acacia saligna – Eucalyptus sp. – Terminalia sp. |
| 13 | Aswan | Nasr El Nouba | 100 | 1400 | Drip Irrigation | Khaya senegalensis – Acacia saligna – Eucalyptus sp. – Terminalia sp. |
| 14 | Beni Sueif | El Wasta | 500 | 10000 | Drip Irrigation | Khaya senegalensis – Jatropha curcas |
| 15 | New Valley | Moot | 700 | 10000 | Drip Irrigation | Terminalia sp. |
| 16 | North Sinai | El Arish | 200 | 15000 | Drip Irrigation | Khaya senegalensis – Jatropha curcas |
| 17 | Assiout | Assiout | 40 | 50000 | Drip Irrigation | Khaya senegalensis – Jatropha curcas |
| 18 | Sohag | West of Sohag | 1000 | 28000 | Drip Irrigation and Modified Flood Irrigation | Khaya senegalensis |
| 19 | Sohag | East of Sohag | 1000 | 28000 | Drip Irrigation and Modified Flood Irrigation | Khaya senegalensis |
| 20 | Red Sea | Hurghada | 200 | 10000 | Drip Irrigation | Casuarina sp. – Khaya senegalensis |
| 21 | South Sinai | Noueiba | 200 | 4000 | Drip Irrigation | Casuarina sp. – Khaya senegalensis |
| 22 | Suez | Attakah | 400 | 30000 | Drip Irrigation | Jatropha curcas – Eucalyptus sp. – Cupressus sp. – Casuarina sp. |
| | Total | | 4840 | | | |

### 2.4.4.2 On-goin Activities and Future Plans

Afforestation are currently cultivated and irrigated by treated sewage water. Some tember forests have been planted, and there are plans for providing necessary funding for cultivating 80 thousand feddans of forest-trees (10 thousand feddans annually), adjacent to sewage water treatment plants on the desert backlog. The project aims to cultivate 400,000 feddans using 2.4 billion cubic meter of treated wastewater annually.

**Tree planting and green areas in Egyptian Governorates**

Tree planting projects and increasing green areas are considered as one of the most important projects given particular concern by the Ministry of State for Environmental Affairs.

The Ministry puts great efforts in contributing in the establishment of gardens in Greater Cairo and all other governorates.

The Ministry has also provided technical and financial contributions for developing slum areas and establishing public gardens and tree planting in their access roads, as well as exploiting empty spaces within cities and residential neighbourhoods to increase green areas.

**Green Belt project around Greater Cairo**

The general objectives of this project are as follows:

- Spreading green areas in available empty spaces around the ring road of Greater Cairo to beautify the capital; develop a feeling and care for trees and the taste of citizens;
- Contributing in environment pollution protection by intensifying greenery around Greater Cairo in order to mitigate harmful and vital impacts affecting public health and safety;
- Investing the areas around Greater Cairo through tree planting for achieving national economic benefit from cultivated trees.

### 3.4.5 Soils

The Nile Delta area covers about 10.000 $Km^2$ (836723 ha) and extends for 175 Km from south to north and 220 Km from east to west along its base at the north. Most of the southern part is now cultivated, while a part of the northern Delta is being occupied by extensive shallow lakes and marshes and in part consists of low-lying salty ground which is under reclamation. The Nile Delta and Valley soils are classified into three main orders namely: Entisols, Aridisols and vertisols.

Table 19: Characteristics and classification of soils in the Nile Delta

| Order | Suborder | Order | Suborder | Great groups | Sub groups |
|---|---|---|---|---|---|
| Entisols | Fluvents | Torrifluvents | Typic Torrifluvent | 6.1 | Sandy loam, fluvial, non saline |
| | | Ustifluvents | Typic Ustifluvents | 1.1 | Fine loam, highly saline, 1% slope |
| | | | Veritc Ustifluvents | 2.0 | Fluviomarine, clay, highly saline 1-2% slope. |
| | Psamments | Quartzi-psamments | Tyic quartzi-psamments | 2.3 | Sandy, slightly saline, 2% slope. |
| Aridisols | Orthids | Salorthids | Aquolic salorthids | 9.9 | Sandy to clay, highly saline, 1-2% slope |
| Vertisols | Torrerts | Haploterrerts | Typic haplotorrerts | 77.1 | Caly, non saline, 1-2% slope |
| | | Salitorrerts | Typic salitorrerts | 1.5 | Clay, highly saline, 1-2% slope |

Table 20: Areas Under Reclamation in Egypt

| Name | Land Management Category | Area Fadden |
|---|---|---|
| **East of Delta**: | | |
| Cairo-Ismailia Desert Road | V | 30.200 |
| Desert fringes Bilbeis | V | 11.600 |
| Adleya/ extension | V | 13.800 |
| Ramsis/ tenth of Ramadan | III | 31.500 |
| El Shebab (youth province) | V | 47.500 |
| Manayif | IV | 37.500 |
| South of Cairo- Ismailia Desert Road | III | 103.600 |
| West of Bitter Lake | III | 38.200 |
| Khahara | V | 27.300 |
| Salhiya Desert | III | 56.000 |

| | | |
|---|---|---|
| Along Huseiniya Lanal | V | 17.000 |
| South Port Said | I | 62.500 |
| East Bahr El Baqqr | I | 11.800 |
| South Huseiniya | I | 72.800 |
| North huseininya | I | 66.000 |
| South port said plain | I | 43.500 |
| El-Matariya | I | 8.900 |
| Faraskur | I | 5.000 |
| **West of Delta:** | | |
| Lake Maryut | I | 11.000 |
| Barseek ( Lake Edku) | I | 27.000 |
| Hager | I | 17.000 |
| East of Desert Road | V | 58.000 |
| Kafr Dawud/ Sadat City | III | 99.600 |
| Bustan | V | 30.300 |
| Bustan extension | V | 18.900 |
| Beheira | III | 92.000 |
| El Nasr Lanal | II | 67.000 |
| Zawyet Sidi Abdel Ati | III | 22.000 |
| El-Hamman | II | 18.000 |
| Ras El Hikma | II | 43.000 |
| El Dabaa | II | 31.200 |
| Shoukry Valley | V | 35.000 |
| **Central Delta :** | | |
| Dry Part of Burnllns | I | 55.300 |
| Baltim and Kashaa | I | 3.700 |
| **Middle Egypt:** | | |
| Upper Wadi Asyut | III | 25.000 |
| Lower Wadi Asyut | III | 5.100 |
| East of Asyut | V | 36.700 |
| West of Manfalut | V | 19.100 |
| West of el Qusiya | V | 12.300 |
| West of Dairut | V | 20.500 |
| Abu Sir | III | 3.700 |
| South El Saff | V | 15.600 |
| North El Saff | V | 23.500 |
| Wadi Arian | | 10.500 |
| **Upper Egypt:** | | |
| Wadi el Kharit | III | 16.500 |
| Wadi Shait | III | 9.500 |
| Wadi Natash | III | 80.000 |
| Tributaries Wadi Natash | III | 22.500 |
| Kom Ombo West | III | 345.000 |
| Wadi El Kobaniya | V | 18.800 |
| El Saayds | IV | 1.000 |
| El Saayda West | III | 81.000 |
| Wadi Seraf | V | 8.400 |
| West Nasim | V | 3.300 |
| Higaza | V | 3.700 |
| Qift | V | 5.500 |
| Wadi Laqeia | V | 48.500 |
| Wadi Qena | V | 1.400 |
| West of Qena | V | 26.300 |
| Wadi Samhud | V | 3.500 |
| West of Girga | V | 3.900 |
| West of Tahta | V | 24.200 |
| Wadi Abu Shih | V | 2.300 |

| | | |
|---|---|---|
| El Ghanayim | V | 3.500 |
| **Sinai:** | | |
| Tina plain | I | 50.000 |
| North Coastal Area | IV | 56.000 |
| East of Bitler Laker | V | 27.500 |
| East of Suez | V | 42.000 |
| El Qaa Plain | III | 2.000 |
| El Arish | II | 1.000 |
| Scahered areas | III | 1.000 |
| **New Valley:** | | |
| El-Zayat | I | 1.500 |
| Dakhla | II | 29.000 |
| West Mawhub | II | 2.000 |
| Abu Minqar | V | 4.500 |
| Farafra | II | 31.500 |
| Karawein | V | 30.000 |
| Bahariya | V | 30.000 |
| Siwa Oasis | V | 23.460 |

*I= Excellent, II= Good, III= Fair, IV= Poor, V= Very Poor, VI= Non-Agriculture*

### 3.4.6 Biodiversity in the Main Nile
### 3.4.6.1 Status and Protection of Species
Egypt's unique geographical position at the junction between two large continents (Africa and Asia), and its inclusion as part of the Mediterranean basin, has permanently influenced both the people and the biota of the country socially, economically and biologically.

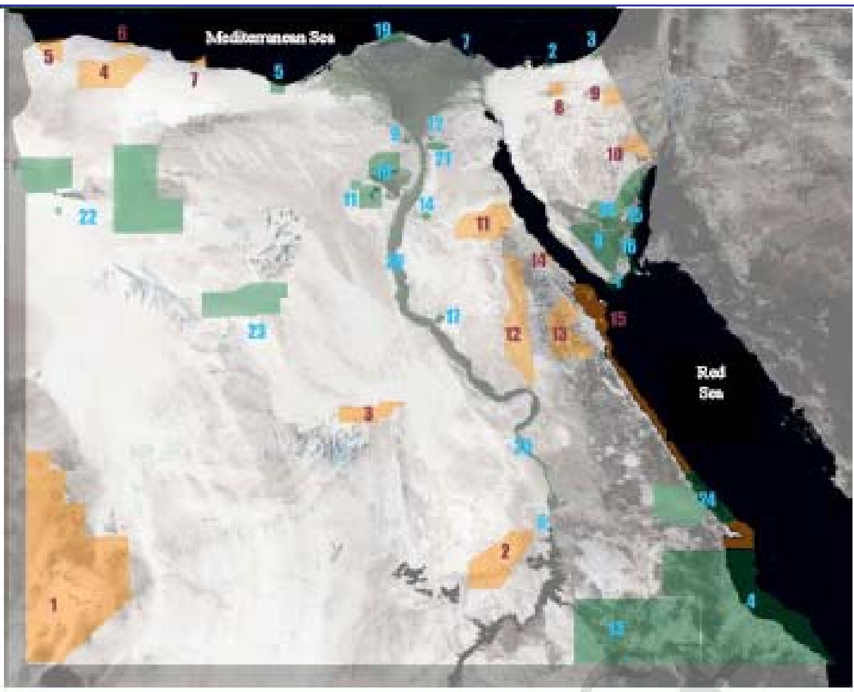
As part of the Sahara of North Africa, Egypt has the climate of the arid Mediterranean region, with notable differences between the coastal and inland areas. Under such harsh geographical and bio climatic conditions, it is to be expected that the biotic wealth of Egypt is not only poor relative to the total area of the country, but also sparse and widely scattered.

In the process of identifying the different types of fauna and flora in Egypt, certain groups (e.g. flowering plants) have been carefully surveyed and well documented, while others (e.g. mosses and liverworts) have not received adequate attention. Each of these habitats has its unique fauna and flora and numerous land and marine areas are listed as protected sites. An estimated 18,000 species of flora and fauna are in Egypt. With regard to flora, there are 44 species of viruses, 238 bacteria, 1,260 fungi, 1,148 algae, 369 non-flowering vascular plants and 2,072 flowering plants species. The fauna include 10,000 species of insects, 1,422 other vertebrates, 755 fishes, 105 reptiles and amphibians, 470 birds and 126 species of mammals. However, until to date, there are no clear statistics that quantify the rate of biodiversity loss in Egypt.

Table 21: Status of Species in Egypt

| Category | Known Species | Common Species | Uncommon Species | Rare Species | Threatened Species | Vulnerable Species | Endangered Species | Extinct Species | Insufficiently known |
|---|---|---|---|---|---|---|---|---|---|
| Marine Algae | 753 | 260 | ---- | 493 | ---- | ---- | ---- | ---- | ---- |
| Freshwater Algae | 871 | 794 | ---- | ---- | ---- | ---- | ---- | 77 | ---- |
| Avifauna | 452 | 436 | ---- | ---- | 5 | 10 | 1 | ---- | ---- |
| Mammals | 98 | 41 | ----- | 28 | ---- | ---- | 10 | 5 | 14 |
| Terrestrial Reptiles | 91 | 41 | ---- | 22 | 11 | 6 | 11 | ---- | ---- |
| Terrestrial Amphibians | 7 | 4 | ---- | 3 | ---- | ---- | ---- | ---- | ---- |
| Freshwater | 4 | ---- | ---- | 3 | ---- | ---- | ---- | 1 | ---- |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Reptiles | | | | | | | | | |
| Freshwater Amphibians | 7 | 3 | ---- | 4 | ---- | ---- | ---- | ---- | ---- |
| Mollusks | 41 | 24 | ---- | 16 | ---- | ---- | ---- | 1 | ---- |
| Echinoderms in the Red Sea, Gulfs of Aqaba and Suez, and Suez Canal | 207 | 131 | ---- | 76 | ---- | ---- | ---- | ---- | ---- |
| Echinoderms in the Mediterranean Waters | 48 | 30 | ---- | 18 | ---- | ---- | ---- | ---- | ---- |
| Cartilaginous Fishes in the Mediterranean | 56 | 12 | 35 | 9 | ---- | ---- | ---- | ---- | ---- |
| Bony Fishes in the Mediterranean Waters | 297 | 84 | 177 | 35 | ---- | ---- | ---- | 1 | ---- |




| Current Protected Areas | | | | | |
|---|---|---|---|---|---|
| 1 | Ras Mohamed | 2 | Zaranik | 3 | Ahrash |
| 4 | Elba and Red Sea islands | 5 | Al Omayed | 6 | Saluga & Ghazal |
| 7 | Ashtum El Gamil | 8 | Saint Katherine | 9 | Dome Hassana |
| 10 | Qaroun Lake | 11 | Wadi El Rayan | 12 | Petrified Forest |
| 13 | Allaqi Valley | 14 | Wadi Sanour Cave | 15 | Abu Galum |
| 16 | Nabq | 17 | Wadi El Asiouty | 18 | Taba |
| 19 | Burulus | 20 | Nile Islands | 21 | Wadi Degla |
| 22 | Siwa | 23 | White Desert | 24 | Wadi El Gemal - Hamata |

| Future Protected Areas | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | El Gilf el kebir | 2 | Kurkur & Dungul | 3 | Om El Dabadib | 4 | El Qasr |
| 5 | El Saloum | 6 | El Shuwaila | 7 | Ras El Hekma | 8 | El Maghara |
| 9 | El Qusima | 10 | Wadi Gerafi | 11 | El Geleala El Qebleya | 12 | Wadi Qena |
| 13 | Shayeb El Banat | 14 | Malahet Ras Shu-qeir | 15 | The Red Sea | 16 | Qattara Depres-sion |

Fig.3: Present and future protected areas in Egypt



Table 221: List of Protected Areas in Egypt

| Protectorates Names | Declaration Date | Type of Protectorate | Area Km2 | Governorate | Prime Ministerial Decree |
|---|---|---|---|---|---|
| Ras Mohamed National Park | 1983 | Wetland | 850 | South Sinai | Decrees 1068/1983 and 2035/1996 |
| Zaranik Protectorate | 1985 | Wetland | 230 | North Sinai | Decrees 1429/1985 and 3379/1996 |
| Ahrash Protectorate | 1985 | Wetland | 8 | North Sinai | Decrees 1429/1985 and 3379/1996 |
| El Omayed Protectorate | 1986 | Desert | 700 | Matrouh | Decrees 671/1986 and 3276/1996 |
| Elba National Park | 1986 | Desert | 35,600 | Red Sea | Decrees 450/1986 and 642/1995 |
| Saluga and Ghazal Protectorate | 1986 | Wetland | 0.5 | Aswan | Decree 928/1986 |
| St. Catherine | 1988 | Desert | 5,750 | South Sinai | Decrees 613/1988 |

| | | | | | |
|---|---|---|---|---|---|
| National Park | | | | | and 940/1996 |
| Ashtum El Gamil Protectorate | 1988 | Wetland | 180 | Port Said | Decrees 459/1988 and 2780/1998 |
| Lake Qarun Protectorate | 1989 | Wetland | 250 | El Fayoum | Decrees 943/1989 and 2954/1997 |
| Wadi El Rayan Protectorate | 1989 | Wetland | 1,225 | El Fayoum | Decrees 943/1989 and 2954/1997 |
| Wadi Alaqi Protectorate | 1989 | Desert | 30,000 | Aswan | Decrees 945/1989 and 2378/1996 |
| Wadi El Assuti Protectorate | 1989 | Desert | 35 | Assuit | Decrees 942/11989 and 710/1997 |
| El Hassana Dome Protectorate | 1989 | Geological | 1 | Giza | Decree 946/1989 |
| Petrified Forest Protectorate | 1989 | Geological | 7 | Cairo | Decree 944/1989 |
| Sannur Cave Protectorate | 1992 | Geological | 12 | Beni Suef | Decrees 1204/1992 and 709/1997 |
| Nabaq Protectorate | 1992 | Wetland | 600 | South Sinai | Decrees 1511/1992 and 33/1996 |
| Abu Galum Protectorate | 1992 | Wetland | 500 | South Sinai | Decrees 1511/1992 and 33/1996 |
| Taba Protectorate | 1998 | Wetland | 3,595 | South Sinai | Decree 316/1998 |
| Lake Burullus Protectorate | 1998 | Wetland | 460 | Kafr El Sheikh | Decree 1444/1998 |
| Nile Islands Protectorates | 1998 | Wetland | 160 | All Governorates on the Nile | Decree 1969/1998 |
| Wadi Digla Protectorate | 1999 | Geological | 60 | Cairo | Decrees 47/1999 and 3057/1999 |

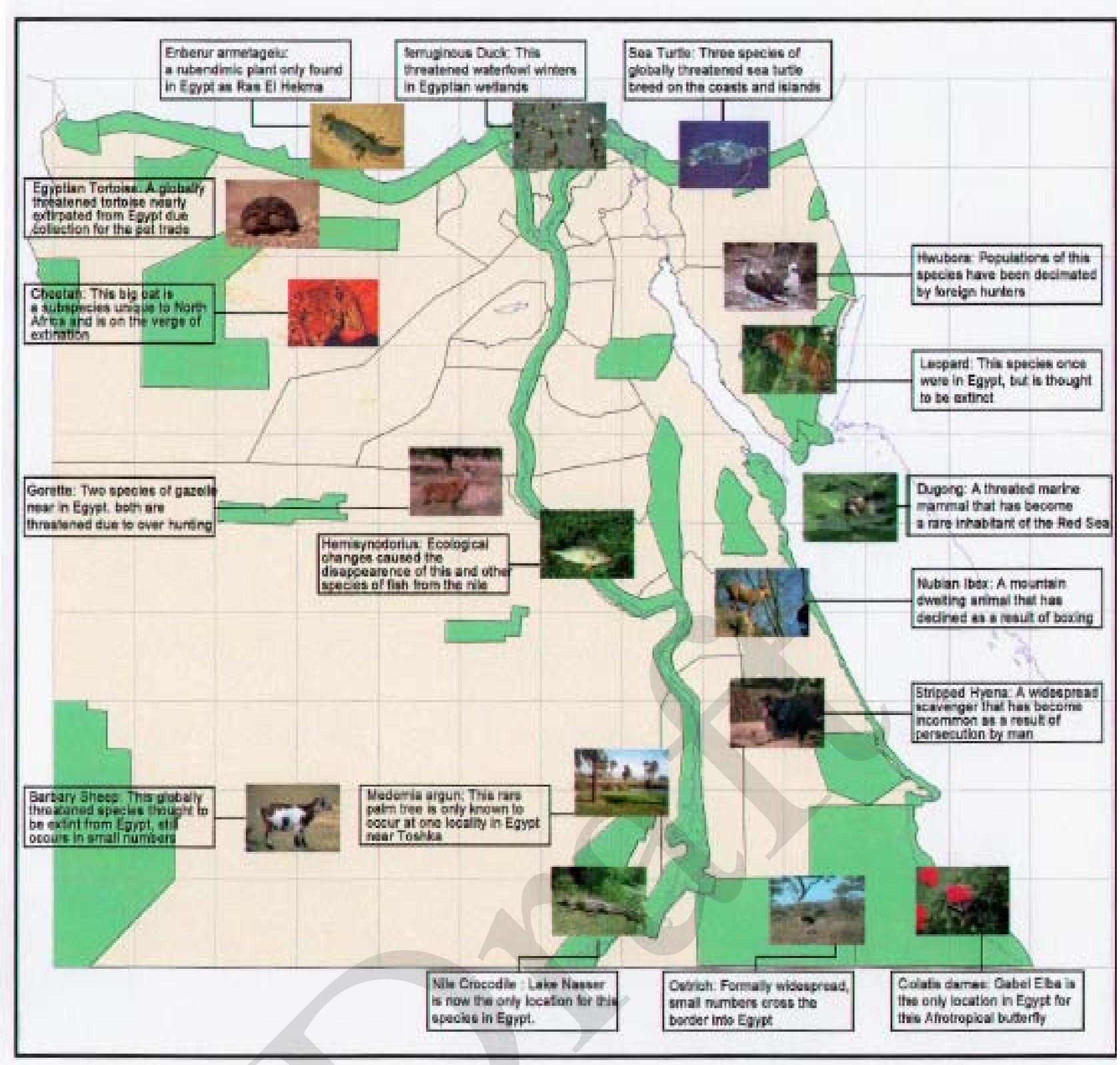



Fig. 4: Location of the protected areas in Egypt

### 3.4.7 Coastal Zone

The Egyptian coastline extends for 3000 kilometres (World Resources 2004) along the Mediterranean Sea and Red Sea beaches in addition to the Suez and Aqaba gulfs. Natural conditions on Egyptian Mediterranean coasts differ significantly from those on the Red Sea coasts in terms of salinity, sea currents and temperature. Such difference has led to different biodiversity and ecosystems in each.

Nearly 40% of industrial development activities are practiced in Egyptian coastal zones, in addition to a number of urban and tourism development activities. Furthermore, coastal zones monopolize the seaports infrastructure, in addition to agricultural and land reclamation sectors, as well as a developed road network capable of accommodating all development aspects. Egyptian coastal zones production is estimated at 85% of Egypt’s production of oil and natural gas; The Gulf of Suez production alone is estimated to be 36 million tons. In addition, the crude oil and natural gas production in the Mediterranean coastal zones is increasing every year.
Through many joint efforts on the regional and international levels under the Global Program of Action for the Prevention of Marine Pollution From Land-based Activities (GPA/LBA & MEDPOL), it was possible to identify many polluted areas in need of urgent action. Most of the adverse impacts were identified and their volume estimated in order to enable their elimination.

Data pointed out to the existence of hot spots that need special attention where pollution has exceeded permissible limits, such as Abu Qir and El Max.

Environmental inspection program results indicated an increase in the number of land-based sources that have adjusted their status and complied with Egyptian Laws and regulations, or that have active environmental compliance programs in place.

Moreover, evidence provided by applied marine environment quality monitoring programs showed a noticeable improvement in the quality of marine environment since the launching of these programs in 1998, particularly in the Mediterranean Sea at the Hot Spots.


Fig. 5: Monitoring sites on Mediterranean Sea and Red Sea

**Implementation of the Environmental Monitoring Program:** The integrated coastal water quality-monitoring program comprises a network of water quality monitoring stations, as reference stations, and other areas for water quality monitoring in polluted areas. Indicators showed a partial improvement in treated sanitation water quality and that most of it was disposed of following different treatment methods. Similar results were provided by marine and coastal environment water quality monitoring programs launched by EEAA, Research institutes in Egypt, the Danish International Development Agency (Danida), and also by pollutants monitoring programs implemented by the Mediterranean Action Plan (MAP) Programs.

The program included continual sample analysis for four years, from about 48 stations on the Mediterranean Sea and 41 on the Red Sea. Monitoring is undertaken once every two months along the Egyptian coast on the Mediterranean Sea from El Saloum to Rafah and from Suez to Shalatin on the Red Sea. A high-quality database was set up for this program based on international standards.

### 3.4.8 Tourism

Egypt, for over seventy centuries, maintained a world culture and civilization that has generously contributed to the rest of the world. Tourism continues to be a main source of hard currency for the country, playing an important role in the balance of payments. The industry currently ranks second among Egypt's major sources of foreign currency.

Tourism is a fast growing sector in the Egyptian economy. More growth is expected in the tourism industry in the coming years as foreign investments continue to increase.

#### 3.4.8.1 Tourism and the Environment

Tourism depends on the environment to sustain it as it relies on the utilization of natural, historical, cultural, and human resources in the local environments. The current boom in the tourism industry is expected to be sustained by developing new types of tourist activities such as safari tourism and eco-tourism.

***Positive Impact***

The generated income from tourism assists in the development and improvements of facilities for protecting and regenerating environmental resources that benefits both the residents and tourists as well. However, in order to reap these benefits better management of tourism is needed and the industry should operate within an overall plan that preserves the natural and cultural heritage of Egypt, upon which the tourist industry depends

***Negative Impact***

The quality of the environment is frequently the primary attraction of tourists. However, their presence in increasing numbers accelerates all the problems caused by human recreational activities. This can lead to a considerable pressure on the environment that attracted tourists in the first place and in particular on the local environment where tourists visit.

The phenomenal coral reef formation is vulnerable to environmental changes, such as climate change. Harmful activities also threaten the existence of coral reefs, such as sewage discharge, spillage and human handling. In addition, fast development of tourism in Hurghada, Sharm El-Sheikh and on the Gulf of Aqaba has led to building more hotels to accommodate for the increase in number of local and international tourists put more pressure on the fragile eco-systems in these areas. Thus, there is a threat to Egypt's coral reefs and immediate action is required to protect this precious natural gift.

#### 3.4.8.2 Eco tourism

Eco tourism can be defined as a purposeful travel to natural areas to understand the culture and natural history of the environment, taking care not to alter the integrity of the ecosystem, while producing economic opportunities that make the conservation of natural resources beneficial to local people.

As mentioned earlier, there are 21 natural protectorates in Egypt. The protectorates can earn some of the money needed for monitoring and maintenance "Travel and Learn" packages to suit the needs of various segments of the population such as schoolchildren, college students, etc… Proper selection of natural protectorates -or even other natural sites- and careful design of "Travel and Learn" packages is a necessary prerequisite to ensure maximum economic benefit.

# 4. POLICIES, LEGISLATIONS, INSTITUTIONAL FRAMEWORKS AND INTERNATIONAL AGREEMENTS

To overcome the existing environmental problems and threats, countries of the Eastern Nile Basin (Ethiopia, Sudan and Egypt) have been formulating, adopting and implementing policies and legislations that could tackle or combat problems related to the environment and water. In order to implement these policies and legislations, they have formed institutions, signed international agreements and prepared action plans.

## 4.1 National Environmental Policies

### 4.1.1 Environmental Policy in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

The Constitutions of Ethiopia recognizes the importance of the protection of the environment and the need for its proper management. These provisions are the major springboards for subsequent legislations in the environmental management, as well as for mainstreaming environmental sustainability in the political, social and economic development sectors.

The overall goal of the nation's environmental policy, approved by the Council of Ministers in 1997, is to improve and enhance the health and quality of life of the people and promote sustainable social and economic development through sound management and use of natural, man-made and cultural resources and the environment as a whole.

Specifically, the policy seeks to:

- Ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained and enhanced;

- Ensure that the benefits from the exploitation of non-renewable resources are extended into the future;
- Identify and develop natural resources that are currently under-utilised by finding new technologies;
- Incorporate the full economic, social and environmental costs and benefits of natural resource development into the planning, implementation and accounting processes by a comprehensive valuation of the environment and the services it provides;
- Improve the environment of human settlements to satisfy the physical, social, economic, cultural and other needs of their inhabitants on a sustainable basis;
- Prevent the pollution of land, air and water in the most cost-effective way;
- Raise public awareness and promote understanding of the essential linkages between environment and development.

Underlying these objectives are a number of key principles that have been established and clearly defined in order to shape all subsequent policies, strategies and program formulations and their implementation.

The Ethiopian environmental policy has the following sectoral issues:

- Improved soil management and sustainable agriculture,
- Forest and tree resources management,
- Genetic, species and ecosystem biodiversity conservation and management,
- Water resources development,
- Energy resources development,
- Mineral resources development,
- Urban Environment and environmental health,
- Control and management of pollution from industrial waste and hazardous materials,
- Control of atmospheric pollution and climate change,
- Conservation and Protection of Cultural and Natural Resources,

The activities undertaken to implement the conservation strategy and the environmental policy are not that much significant. However, the following major activities have been undertaken:

- The Environmental Protection Authority has been established at the federal level;
- Three regional states have established their own environmental organs;
- Proclamations for pollution control, environmental impact assessment, and for the establishment of environmental protection organs have been enacted;
- The National Plan of Action to Combat Desertification has been prepared;
- The Environmentally Sustainable Industrial Development Strategy has been prepared; and
- The Environmental Protection Authority's organizational structure has been revised

However, in spite of those activities, no evaluation has been carried out regarding the implementation of the policies, the guiding principles and the strategies.

In the lower part of those sub basins in the Sudan, environmental policies and legislation are embodied in the various legislations and policies developed by the different Ministries and institutions. This has resulted in malfunctioning in the planning and consequent implementation, in addition to poor coordination among the various concerned agencies.

The following are examples of relevant national policies and strategies:

- The 25 Year (2003–2027) draft Strategic Plan containing five sectors, namely political development and sovereignty, economic growth, Guidance and social care, Services and private and civic society;
- The National Comprehensive Strategy (NCS) (1992-2002), which provided policy directions to all economic and social sectors;
- National Economic Salvation Program (NESP) (1992-1993) emphasizing reforms aimed at removing structural and institutional rigidities
- The Joint Assessment Mission (JAM) (2005), guiding the economic development in post peace period in Sudan;

- Poverty Reduction Strategy (2000), considered to be the main available document of the government of the Sudan for poverty reduction;
- National Water Policy (2001)/draft, emphasizing on the adaptation of water policy to meet the changing circumstances in the country, ensuring the proper management, protection and utilization of water resources, providing the basis for the on-going development of water related regulations and legislations, and strengthening and clarifying the functions and responsibilities of water related institutions

### 4.1.2 Water Policy in the Main Nile (Egypt)

In the Main Nile, the National Water Policy has been prepared till the year 2017 including three main themes, namely:

- Optimal use of available water resources;
- Development of water resources; and
- Protection of water quality and pollution abatement.

At present, the issue of limited water quantity is being addressed by managing the demand side; and a water master plan, aiming to allocate available water resources according to various needs, is currently updated. The NWRP, which is directed towards developing a National Water Resources Plan that describes how Egypt will safeguard its water resources both in quantity and quality and how it will optimise the use of these resources, has been operational since 1998.

#### 4.1.2.1 Optimal Use of Available Water Resources

In the mean time, the government of Egypt intends to reclaim an area of 3.4 million acres to increase the current 8.0 million acres of agricultural land. To implement these ambitious policy themes, MWRI has embarked on several programs including the improvement of the irrigation systems on the level of branch and field canal in an area of around 400,000 acres in the old land. It is expected that this outcome of this program will help in saving the irrigation water by 5-10 percent. Also, there would be installation of the Nile drainage systems in an area of five million acres and rehabilitation of old drainage network in another 1.5 million acres. This would leach salt from the soil profile and improve the soil fertility. Other programs are the rehabilitation of irrigation and drainage pumping stations, introducing new crop varieties that early mature and salt tolerant; and replacing and rehabilitant the existing grand barrages and structure on the Nile and main canals.

Moreover, there are sets of strategies proposed to:

- Minimize Water Loses ;
- Improve Irrigation Project; and
- Shifting crop ppattern;

#### 4.1.2.2 Groundwater Development Strategies

The groundwater policy aims to encourage agricultural development of desert areas. These areas will be the basis for initiating new communities that can absorb part of the highly concentrated population in the Nile valley and Delta. The expected increase in the future demands for groundwater requires continuous monitoring and evaluation of the groundwater aquifers to avoid any possible deterioration in these aquifers due to miss or over use.

The groundwater in the Nile valley and Delta region cannot be considered an independent resource as it gets recharged only from seepage losses, the River Nile canal and drainage networks; and from deep percolation losses of irrigated land. The strategy of groundwater depends on the conjunctive use of Nile surface and groundwater through:

- Utilization of the aquifer as a storage reservoir used to supplement surface water supply during peak periods and recharged during the minimum demand periods;
- Use the vertical wells drainage system in Upper Egypt to prevent the groundwater table from reaching the root zone avoiding water logging and increasing productivity;
- Groundwater could be used as a source of water for fish farms as it has consistent and steady temperature and good quality; and
- Augment the canal water supply by pumping groundwater from low capacity private wells at tail ends of long *mesqas* where water shortage is experienced.

Groundwater in parts of the Western Desert and Sinai is very deep and this needs huge investments to be utilized. Therefore, future strategies for best utilizing groundwater in the Western Desert and Sinai include:

- Use of the modern technologies for determining the main characteristics of each aquifer, its maximum capacity and safe yield. This data should be the basic criteria for selecting the most suitable projects that could use such aquifers as a sustainable source of water;
- Use of non-conventional sources of energy, such as solar and wind energy to minimize the costs of pumping;
- Use of new technologies for farm irrigation in desert areas to minimize field losses especially deep percolation due, in part, to the high porosity of such soils.

**4.1.2.3 Reuse of Agricultural Drainage Water**

MWRI is considering drainage water reuse as a main source to meet part of the irrigation water demands. The reuse of drainage water increases the overall efficiency of the water system; but it must be regulated to prevent future environmental impacts. Future strategies for drainage water reuse are as follows:

- Increase the amount of drainage water reuse from about 5.0 BCM/ year in the year 2000 to around 9.0 BCM/year by year 2017 with average salinity about 1170 ppm. This could be achieved through implementing several projects to expand the reuse capacity at different areas. Main future projects include El-Salam canal project, El-Umoum Drain project, and El-Batts Drain project;
- Establish an integrated information system for water quality monitoring in drains using the existing data collection network; and
- Continuous monitoring and evaluation of the environmental impacts due to the implementation of drainage water reuse policy especially on soil characteristics, cultivated crops, and health conditions.

**4.1.2.4 Reuse of Sewage Water**

The MWRI future policy for utilization of such source could be summarized as follows:

- Increase the amount of secondarily treated wastewater use from 0.26 to 2.8 BCM/year by year 2002 and to 4.5 BCM/year by year 2017;
- Limit the use of treated wastewater to cultivate non-eatable crops, such as cotton and flax;
- Separate industrial wastewater from domestic sewage, so that it would be easier to treat domestic sewage with minimum costs and avoid the intensive chemical treatment needed for industrial wastewater.

**4.1.2.5 Water Resources Development**

MWRI is investigating the possibilities of developing new water resources or increasing the availability of existing resources to meet future increasing demands. In that regard, the future water policy for Egypt will include the following strategies:

**4.1.2.6 Increase Egypt's Share of the Nile Water**

Almost 85 percent of the Nile water originates from the Ethiopian highland through the Sobat River, the Blue River Nile, and the Attbara River. The rest originates from the Equatorial Lakes Plateau through Bahr El-Ghabal. A very small portion comes from Western Sudan through Bahr El-Ghazal. According to the Nile water treaty with Sudan, Egypt's share of the water was fixed at 55.5 BCM/year by the year 1959.

Bilateral cooperation with the River riparian started through joint agreements to develop the River-shared resources. Studies clarified that large amounts of Nile water is lost before it reaches Aswan. Accordingly, there is a modest potential to decrease these losses through implementing joint projects with other countries in the Nile basin. Three projects had been identified, namely, Jongli Canal, Bahr El-Ghazal, and Mashar Marshes projects, which will add about 9 BCM/year to Egypt's share of Nile water. However, the MWRI does not entirely depend on these projects, as they will be implemented outside the borders of the country and require great efforts in the sphere of political negotiation and cooperation among the countries of the River Nile.

Since the cooperative development holds the greatest prospect of bringing mutual benefits to the region, the Nile riparian, including Egypt, has taken a historic step in the establishment of the Nile Basin Initiative (NBI). The Council of Ministers of Water Affairs of the Nile Basin States formally launched the Initiative in February 1999. The initiative includes all Nile countries; and provides an agreed basin-wide framework to fight poverty and promote socio-economic development in the region. The Nile countries seek to realize their shared vision through a Strategic Action Program, comprising basin-wide projects, as well as sub-basin joint investment projects. The basin-wide Shared Vision Program, a broad based program of collaborative action aims at exchanging experience and promoting capacity building activities. At the same time, group of other countries, one in the Eastern Nile and another in the Nile Equatorial Lakes region, have identified joint, mutually beneficial investment opportunities at the sub-basin level.

#### 4.1.2.7. Desalination of Brackish Water

The MWRI is looking for the utilization of the low salinity brackish groundwater in irrigating certain seasonal crops. This amount of water is available at shallow depths in the Western and Eastern Deserts and at the borders of the Nile valley. The average salinity of such water varies from 3000 to 12000 ppm. The future strategy of the MWRI in that regard takes the following into consideration:

- This source of water can be considered an independent resource that can be used as a supplementary water supply source to meet part of the water demands in desert areas, especially near to the northern shoreline. The level of treatment of this water will depend on the type of use whether it will be for municipal or agriculture needs. This amount of water could be used with minimum treatment to irrigate certain perennial or seasonal crops;
- Non-conventional sources of energy, such as solar and wind energies could be used in the treatment process to minimize the cost and increase its economic value; and
- This source will be used as a supplementary source to rainfall water to increase land productivity by cultivating two crops per year instead of one.

#### 4.1.2.8 Harvesting of Rainfall and Flash Floods Water

Studies indicate the possibility to conserve about 2.0 BCM/year from flash floods. MWRI considers the flash flood on the top priorities of the national agenda, because of its economic benefits and negative social impacts. The future strategies of the MWRI for flash flood risk assessment and utilization considers the following:

- Use of modern technology in remote sensing areas and GIS to examine the basic characteristics of the stream network that contribute to flash floods;
- Adjust High Aswan Dam daily release during the occurrence of flash floods over a certain area that drains its water to the River Nile; and
- Avoid hazards from flash floods by designing risk zone maps for major bottlenecks on the basin streamlines. Furthermore, identify areas that lie in risk zones to take proper precautions to avoid any possible hazards.

#### 4.1.2.9 Water Quality Protection and Pollution Abatement

**Policy Theme**

The policy theme is realized through preventive measures and long-term policies. The preventive measures are carried out through the regular assessment of the water quality status and suitability for various uses. Moreover preventive measures include enforcement of laws to protect water resources from pollution. The Ministry of Water Resources and Irrigation formulated a National Program for Water Quality Monitoring in the Nile, canals and drains and Lake Nasser. The Central Laboratory carries out the substantial lab work for Environmental Quality Management affiliated to National Water Research Centre. The monitoring program includes 300 locations for surface water and 230 locations for groundwater. The long term policies to control pollution include covering open conveyance system passing through urban system to closed conduits; coordinating with other concerned ministries to set priorities for wastewater treatment plants due to budget limitation; introducing environmentally safe weed control methods either mechanical, biological or manual and banning the use of chemical herbicides. Subsidies on fertilizers and pesticides were removed and some long lasting agricultural chemicals were also banned. Public awareness programs are introduced to promote the issue of conserving Egypt's water resources in terms of quality and quantity.

**Water Quality Management**

As the quality of water gets worse, its scope of use narrows, reducing supplies and intensifying shortages. The MWRI in coordination with the other concerned ministries and authorities are implementing a long-term strategy for preventing pollutants from discharging into the Nile and other water bodies. The implementation of this strategy requires a comprehensive database that includes maps, and also an electronic database, a design for landfill sites based on sound hydro geologic information and impact assessment. The MWRI will establish a Water Quality Management Unit in co-operation with the Netherlands Government. The objectives of this unit are as follows:

- To co-ordinate between all related activities within the Ministry and its research institutes and the executive departments and authorities;
- To develop and execute training packages;
- To develop public awareness campaigns directed to other governmental sectors, stakeholders and the public;
- To develop strategic water quality plans on the regional and national level in cooperation with other ministries and stakeholders; and
- To develop water quality database.

Other major project implemented by the MWRI is the National Water Quality and Availability Management (NAWQAM) project. This project is directed towards developing a coordinated national system for sustainable water resources management in Egypt. The Egyptian institutions, in particular the MWRI have the capacity to manage water resources from a national perspective through the participation of other stakeholders and the usage of collaborative techniques. This includes the following activities:

- Building the MWRI capacity to prepare sustainable and comprehensive environmental analysis with regard to water quality and availability;
- Developing the management and professional capacity of organizations working in the issue of water quality and availability to effectively prepare policy options, make operational decisions based on improved "national level" data, and incorporate environmental analysis;
- Rationalizing water quality monitoring activities in a sustainable manner; and
- Utilizing applied research and pilot projects to prepare guidelines towards implementing national strategies and action plans.

#### 4.1.2.10 Coastal Lakes Management

Degradation of the water quality of Egyptian lakes is due, in part, to the uncontrolled discharge of human, industrial and agricultural wastewater. Fish production from the lakes along the Mediterranean coastal plain is estimated to be about 38 percent of the total fish production. The primary water concern is to prevent the water quality from deteriorating to the point of threatening fisheries production. Most vulnerable are the brackish Northern Coastal Lakes, where they are located at the end of the Nile system and have been exposed to changes in salinity. In addition, these lakes are losing their attraction as recreational resorts. These circumstances negatively affect the livelihoods of the population who depend on these lakes.

The Ministry of Water Resources and Irrigation and the EEAA have developed a program listed in National Strategy for Lakes rehabilitation and conservation with the full support of the communities living around these lakes. The activities of this program are to design and implement a monitoring program and to identify and control sources of pollution.

#### 4.1.2.11 Coastal Water Management Scheme

The MWRI developed a sustainable management scheme for coastal waters in Egypt. An integrated plan for managing and protecting coastal water quality is the output of this program. The expected results of implementing this plan are improved water quality that will have positive economic and financial returns on the cost of the program formulation and implementation.

The activities of this scheme include:

- Update and extend existing contingency plans;
- In collaboration with relevant authorities, develop a system to control sources of pollution;

- Set criteria for brine disposal to the marine environment; and
- Support wider ratification and implementation of relevant shipping conventions and protocol.

**Drinking Water Losses**
One of the major problems in potable water supply is the estimated 50 percent loss of water in the distribution networks. This problem costs the Government a huge amount of money every year. The annual amount of lost water in networks is estimated at 2.95 BCM. If the estimated cost of operation and maintenance for one cubic meter is L.E. 0.45, the annual wasted fund is almost L.E. 1.3 billion. This amount is equivalent to the total annual investment of the National Organization for Potable Water, And Sanitation Drainage (NOPWASD).

**Poor Quality of Drinking Water**
Poor quality of drinking water is a concern in many parts of Egypt. This is due, in part, to the fact that sources of raw water for many areas have become increasingly polluted, and therefore require more sophisticated treatment to produce drinking water of adequate quality. Furthermore, water treatment units are not always functioning properly as a result of lacking maintenance and proper operation. Even when water treatment is satisfactory, drinking water is sometimes contaminated in leaking distribution network, which are infiltrated for example by sewage. Rooftop water storage tanks have also been identified as another source of bacterial contamination of drinking water.

**High Domestic Water Consumption**
Water has traditionally been viewed as a free commodity in Egypt. Government subsidies encourage wasteful practices. The price of water does not reflect the actual cost for providing it. Therefore, there has been no strong incentive for consumers to use water rationally and consequently the per capita water consumption is high, especially in areas where the water supply systems are well functioning.

The general policy of the government of Egypt with regard to the water supply sub-sector is to increase the efficiency of water utilities and shift from service beneficiaries to utility income. In order to achieve this target we need to establish a database for the uncovered areas. This will help planning for the full coverage with safe drinking water to all rural and urban formal and informal settlements.

**4.1.2.12 Water Quality Management Program**
The Ministry of Water Resources and Irrigation has developed a program that aims to improve the quality of drinking water in Egypt. This program will minimize the potential health hazards resulting from water borne diseases. The program can generate financial returns plus its economic impact on the Egyptian society. The activities of this program will be as follows:

- To provide uncovered areas with safe drinking water.
- To develop an alternative system for production and distribution of drinking water employing user pay principle.
- To evaluate the use of compact systems.
- To develop appropriate systems for iron and manganese removal.
- To develop appropriate systems for micro-pollutants removal.
- To provide technical support for institutional structure.
- To develop training programs on operation, maintenance, analysis and record keeping, etc.

Enhancing the performance of treatment and distribution systems is an expected outcome of this program. Full coverage with safe drinking water will be achieved according to GOE plans.

**4.1.2.13 Wastewater Management**
**Domestic Wastewater**
The total amount of domestic wastewater has been estimated at 3.6 BCM for the year 1995/96.

Approximately 24 percent of the population of Egypt is connected to sewerage services; however this value is expected to grow rapidly, due to works under construction. The population without connection to sewerage systems relies on individual means of treatment and disposal, mainly on-site treatment such as septic tanks. Often on-site solutions are ill designed and poorly maintained. There is, however, little information available to support this argument.

An assessment of water quality in Egypt indicated that the major water quality problems are pathogenic bacteria/parasites; heavy metals and pesticides. Major sources of these pollutants are the uncontrolled discharge of human, industrial and agricultural wastes.

**Agriculture Wastewater**

Agriculture is also a major water polluter. Wastewater seeping from agriculture fields is considered non-point sources of pollution. These non-point sources are, however, concentrated through collecting agricultural drains from point sources of pollution for the River Nile, the Northern Lakes or irrigation canals in case of mixing water for reuse. Moreover, these non-point sources of pollution may also influence the groundwater quality. Major pollutants in agricultural drains are salts; nutrients (phosphorus and nitrogen); pesticide residues (from irrigated fields), pathogens (from wastewater), and toxic organic and inorganic pollutants (from domestic and industrial sources).

**Industrial Wastewater**

Industrial use of water in Egypt is estimated at 7.5 BCM/year in 1999. The industrial use of water is expected to increase. Consequently, an increase in the volume of effluents is expected. Industrial wastewater contains a variety of toxic organic and inorganic chemicals, which are potential health and environmental hazard.

#### 4.1.2.14 Sanitation Management Program

The Ministry of Health and Population in collaboration with the Ministry of Housing, Utilities and Urban communities and other local agencies have developed a program to protect the environment and public health through a comprehensive, integrated scheme for wastewater collection and treatment. This program aims mainly to induce institutional reforms that promote the implementation of non-conventional low-cost technology, simplification of procedures, changes in both attitudes and behaviour, and participation of major population groups, particularly women. Other objectives include evaluating the environmental health and socio-economic impacts; and determining the socio-economic benefits of sewerage treatment.

The activities of this program include:

- Develop and implement low cost technologies for domestic wastewater treatment taking into account some traditional and indigenous practices.
- Development and implementation of decentralized systems to increase the potentiality for reuse taking into account some traditional and indigenous practices;
- Prepare training packages for engineers, chemists, technical operators, and workers associated with the developed wastewater management activities;
- Devise an equitable system to finance the cost of extending sanitation services to non-served areas, to close the gap between rural and urban areas; and
- Strengthen the institutional structure.

The output of this program is serving areas that lack sanitation, thus improving the quality of life. This will have its own economic and financial gains, once a system that deals with sanitation as a revenue generating activity is in gear. The supportive measures for this program include addressing the existing institutional and financial constraints to enhance the inspection authority of the EEAA to ensure the effective implementation of the law.

## 4.2. Environmental Regulatory and Legislation

### 4.2.1 Regulations and Proclamations in Tekeze-Atbara-Setit, Baro-Akobo-Sobat, White Nile and Blue Nile

#### 4.2.1.1 Environmental Proclamations

Based on the Constitution, three different proclamations have been drafted in the upper part (Ethiopia) of the sub basins, namely:

- Proclamation for the Establishment of Environmental Protection Organs
- Environmental Pollution Control Proclamation
- Environmental Impact Assessment Proclamation

In addition to the overall proclamations, environment-related sectoral proclamations and regulations are being implemented. These are:

- Forestry Proclamation No. 94/02
- Mining Works Council of Ministers' Regulation 82/98;
- Labour Proclamation No, 45/95;
- Investment Proclamation No 37/96;
- Commercial Registration and Business License Proclamation No. 67/97;
- Water Resources Management and Administration Proclamation No. 197/2000;
- Environmental Health Proclamation No. 200/2000;
- Mining Proclamation of 2001;
- Radiation Protection Authority Establishment Proclamation No. 79/1993; and
- Urban Zoning and Construction Permit Proclamation.

The Environmental Impact Assessment Proclamation of 1995 incorporates Project, Strategic and Social Impact Assessment. Therefore, the implementation of projects, programs or policies likely to have environmental impact shall not be allowed unless they include impact mitigation and contingency plans. As the proclamation provides a framework for strategic environmental impact assessment, the problems that existed in this regard in the past are considered to have found a solution.

#### 4.2.1.2 Environmental Guideline

In Ethiopia, there has not been any environmental guideline in the past. However, following the establishment of the Environmental Protection Authority, sectoral Environmental Impact Assessment guidelines focusing on agriculture, transport, industry, tannery and settlements have been prepared.

In addition to these, a general guideline for facilitating EIA in all sectors has been prepared. The fundamental purpose of the guideline is to ensure that proponents, the government and all other interested and affected parties have the opportunity to participate meaningfully in the EIA process.

In addition, the Authority is preparing guidelines for the preparation of projects for the follow-up and supervision of environmental matters to be submitted to the Global Environmental Facility.

The Environmental Impact Assessment Guideline focuses on the implementation of the following principles:

- The application of the EIA process at an early stage investment planning;
- The participation of all interested and affected parties in the process;
- The consideration of all feasible alternatives (for example: - alternative sites or sources of raw materials as well as a "no-go" option) for the project; and
- The application of an operational system that ensures transparency and accountability.

The participation of interested or affected parties at all the critical stages of the EIA process is stated as a prerequisite. At the federal level, coordination of Environmental Impact Statement (EIS) is the mandate of the Environmental Protection Authority, and of regional environmental agencies at the regional level.

**In the lower parts of the three Sub Basins (Sudan),** the Higher Council for Environment and Natural resources (HCENR) initiated the development of environmental regulations called the Environment Protection Act in 2001, which was issued through a presidential decree. It established guidelines and requirements for environmental impact assessments and environmental conservation frameworks. The Environmental Protection Policy (2001) requires that any new projects, that are deemed to have an impact on the environment, to conduct an Environmental Impact Assessment (EIA) in order to ultimately obtain an Environmental Compliance Certificate (ECC) from the HCENR through the receipt of an Initial Environmental Impact Assessment (IEA) report containing a Mitigation Plan or a description of the mitigation measures to be implemented to reduce the environmental impacts of the proposed project. The EIA report is normally made available for viewing and comment by interested and affected parties prior to the HCENR giving the go ahead with the project. This legislation represents a major step in coordinating national developmental projects on an environmentally sustainable basis.

### 4.2.2 Environmental Legislation in the Main Nile (Egypt)

There is a wide variety of legislation in Egypt for the control of the impact of human activity to minimise its harmful and nuisance impacts on the environment. Thus, this environment legislation is concerned with surface water contamination, soil pollution and degradation, air contamination, noise, energy consumption and effects on human beings and other living organisms.

Other legislation is concerned with the impact of the human exploitation of natural resources; the visual effects of building developments and redevelopments; that may harm sites of historic/ architectural / archaeological importance.

A legal basis for controlling water pollution exists through a number of laws and decrees. Law 48/1982 regarding the protection of the river Nile and other waterways from pollution, and Law 4/1994 on Environmental protection are the most important ones and are discussed below.

#### 4.2.2.1 Law 48/1982 and Decree 8/1983

Law 48 of 1982 specifically deals with discharges to water bodies. This law prohibits discharge to the river Nile, irrigation canals, drains, lakes and groundwater without a license issued by the MWRI. Licenses can be issued as long as the effluents meet the standards of the laws. The license includes both the quantity and quality that is permitted to be discharged. Discharging without a license can result in a fine. Licenses may be withdrawn in case of failure to immediately reduce discharge, in case of pollution danger, or failure to install appropriate treatment within a period of three months.

Under the law, the Ministry of Interior has police power while the Ministry of Health and Population is the organization responsible to give binding advice on water quality standards and to monitor effluents/discharges. Law 48 does not cover ambient quality monitoring of receiving water bodies although some standards are given.

- Law 48 recognizes three categories of water body functions:
- Fresh water bodies for the Nile river and irrigation canals;
- Non-fresh or brackish water bodies for drains, lakes and ponds;
- Groundwater aquifers.

Ambient quality standards are given for potable resources, which are intended as raw water supplies for drinking water. The implementing Decree 8 of 1983 specifies the water quality standards for the following categories:

- The Nile river and canals into which discharges are licensed (article 60);
- Treated industrial discharges to the Nile river, canals and groundwater;
    - Upstream the Delta barrages discharging more than 100 m3/day (article 61);
    - Downstream the Delta barrages discharging more than 100 m3/day (article 61);
    - Upstream the Delta barrages discharging less than 100 m3/day (article 62);
    - Downstream the Delta barrages discharging less than 100 m3/day (article 62);
- Drain waters to be mixed with the Nile river or canal waters (article 65);
- Treated industrial and sanitary waste discharges to drains, lakes and ponds (article 66);
- The drains, lakes and ponds into which discharges are licensed (article 68);

Discharge of treated sanitary effluents to the Nile River and canals is not allowed at all (article 63) and any discharge of sanitary waste into other water bodies should be chlorinated (article 67). The water quality standards are generally based on the drinking water standards and are not linked to all other functions a water body may have. The use of agrochemicals for weed control is also regulated in the law.

#### 4.2.2.2 Law 4/1994

Through Law 4 of 1994, the EEAA is the authority responsible for preparing legislation and decrees to protect the environment in Egypt. The agency also has the responsibility for setting standards and for carrying out compliance monitoring. It should participate in the preparation and implementation of the national program for environmental monitoring and utilization of data (including water quality). The agency is also charged with establishing an "Environmental Protection Fund" which would include water quality monitoring.

With respect to the pollution of the water environment, the law states that all provisions of Law 48/1982 are not affected and further, Law 4 only covers coastal and seawater aspects. Nevertheless, a number of issues are unclear**:**

- The MWRI remains the responsible authority for water quality and water pollution issues, although the definition of "discharge" in Law 4 specifically includes discharges to the Nile River waterways. EEAA is responsible for coordinating the pollution monitoring networks;
- In Law 4, it is stated that all facilities discharging to surface water are required to obtain a license and maintain a register indicating the impact of the establishment's activity on the environment. The register should include data on emissions, efficiency and outflow from treatment units and periodic measurements. EEAA will inspect the facilities yearly and follow-up any non-compliance. This provision is confusing or creating duplication because Law 48/1982 also includes certain standards for effluents with MOHP as compliance monitoring organization and only MOHP laboratory results are considered to be official; and
- Both laws create funds where fines are collected and which are used to fund monitoring and other activities.

#### 4.2.2.3 Gaps and Overlaps in the Legislation

Various aspects of environmental protection were addressed before Law 4/94. These were traditional regulatory measures that focused on end-of-pipe controls implemented through command-and-control regulations. Not surprisingly the result is piecemeal, leaving gaps and causing overlaps. Law 4/94 was a step towards introducing more flexible and more effective tools for dealing with environmental problems. The source of institutional overlap between ministries and agencies involved with environmental issues lies with the originating legislation.

#### 4.2.2.4 Compliance with Environmental Laws and Regulations

The environmental laws that are regulating the environment in Egypt include penalties to those who do not abide with the law. These penalties may tackle the form of restricting the freedom of the citizens who break the law or charge financial fines. Enforcing environmental law is done through specified responsible agencies. Enforcing the law is achieved through various means such as regular administrative inspection, sudden inspection and complaints from individuals or NGOs. Egyptian environmental laws have not been enforced adequately for a variety of reasons, including:

- Lack of adequate authorities with necessary resources to carry out inspection and enforcement;
- Lack of public awareness regarding the magnitude of the environmental problems and their negative effects;
- The regulatory approach is not effective because standards generally do not allow the flexibility necessary for the polluter and the regulatory agency to negotiate quick agreement on a compliance schedule;
- Instead, Egyptian regulators concentrate on informing the polluter of a violation, but there are no provisions for phasing in compliance measures after the violation has been announced and; and
- There is no sufficient coordination and cooperation among the ministries and governmental institutions regarding the issue of environmental protection.

#### 4.2.2.5 Biodiversity National Legislation

The legislative tools for biodiversity conservation and sustainable development in Egypt were issued as laws and ministerial decrees and can be summed up in chronological order as follows:

- Law 53 of 1966 (also known as "The Law of Agriculture" ). Among the numerous articles and clauses of this law, article 117 prohibits the hunting of birds and other wild animals useful to agriculture. It also bans the trading and killing of these birds as well as the destruction of their nests. Article 118 of the same law prohibits the cultivation of plants harmful to these birds and wild animals, bans the importation of material used in their hunting and prevents the use of all forms of traps. The prevention of cruelty to animals is spelled out explicitly in article 119;

- Ministerial decree 28 of 1967 specified the species of birds and other wild animals under protection covered by article 117 of the previous law 72 of 1968 concerning the prevention of pollution of seawater by oil.
- Ministerial decree 349 of 1979 established the Egyptian Wildlife Service as the first governmental authority concerned with the protection of wildlife in the country;
- Ministerial decree 66 of 1982 prohibited hunting all species of birds and other wild animal in certain areas of the Sinai Peninsula, as well as fishing and catching all species of molluscs and corals in various other specified regions;
- Law 48 of 1982 for the protection of the River Nile and other water courses against pollution. It prohibits the discharge of solid, liquid and gaseous wastes with certain levels of pollutants into the Nile and all freshwater bodies; while the Ministry of Irrigation determined the maximum allowable levels of polluting elements in such wastes, the Ministry of Health is empowered to carry out the required analysis of samples of these wastes;
- Law 102 of 1983 set up the legal framework for the declaration and management of protected areas and regulates the conservation of natural resources;
- Law 101 of 1985 levied an additional tax on aeroplane tickets issued locally, in order to secure a suitable source of funding to finance programmes for developing tourism and environmental protection; and
- Law 4 of 1994 is by far the most comprehensive environmental legislation to date. It authorizes the EEAA to prepare an Environmental Contingency Plan (article 25), and forbids the hunting of specified types of wild birds and animals (article 28) as well as the destruction of their natural habitats.

#### 4.2.2.6 Laws and Legislation of Pesticide Applications

The pesticide monitoring law No. 53 of 1966 and the supplementary decrees No. 215, 381 and 256 issued in 1985, 1988 and 1990, control the introduction and handling of pesticides in Egypt. According to the law, a Pesticide Committee (PC) under the Ministry of Agriculture (MOA) and the Ministry of Health (MOH) is responsible for enforcing the law. Introduction of new pesticides in Egypt include the procedures of registration, formulation and importation, and control on the use and handling of pesticides. The control is carried out by inspectors posted in each agricultural department of the Ministry of Agriculture and the Central Pesticide Laboratory in Cairo.

New pesticides are only accepted in the country after a long application procedure. This includes registration, followed by a period of testing during 3 years of field trials in which the effectiveness of the pesticide against the pest is investigated. The registration includes such data as the recommended rate of usage, treatment after misuse (poisoning), production data, warning signs and toxicological data. After acceptance and recommendation of the pesticide, these data must be indicated on the pesticide package. Upon importation of large quantities of pesticides, PC is authorized to take representative samples of the pesticides to check the chemical and biological contents.

## 4.3. Institutional Frameworks and International Agreements

### 4.3.1 Institutional Frameworks in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

#### 4.3.1.1 Upper Part of the Sub Basins (Ethiopia)

The introduction of the federal system in Ethiopia has changed the balance of power in favour of the newly created regional states, which have legislative, executive and judicial powers within their jurisdiction. The goals of decentralization include increased administrative efficiency, local participation in development planning and management and the allocation of resources.

At the federal level, the Environmental Protection Authority has been established with the objectives of co-ordinating and regulating activities in the environmental management field to ensure that all matters pertaining to the country’s social and economic development activities are carried out in a manner that will protect the welfare of human beings.

In earlier days, natural resources development and environmental protection activities were carried out in a dispersed manner among sector institutions. In 1985, natural resources protection and development was attached to the Ministry of Agriculture as a distinct sector led by a vice minister. This lasted until 1993.

In 1993, the Ministry of Natural Resources Development and Environmental Protection was established. This new institution functioned until 1995, when it was replaced by the Environmental Protection Authority, by virtue of Proclamation No. 9/95.

In accordance with the duties and responsibilities entrusted upon it, the Authority has been undertaking various activities related to environmental protection until 1992. However this earlier enabling proclamation has now become repealed and replaced by the new proclamation which provides for the establishment of environmental organs because it was considered important:

- To facilitate the sustainable use of environmental resources by eliminating conflicts in mandates and duplication of work by allocating to separate institutions activities related to environmental development and management on the one hand and environmental regulation and supervision activities on the other hand; and
- To establish a mechanism which will strengthen the carrying out of the distinct organisational responsibilities of federal and regional environmental organs in a coordinated manner.

The Proclamation also has other articles that treat the conditions under which sectoral environmental units and regional environmental offices are to be established with full details of their duties and responsibilities.

This institutional set up is believed to facilitate the integration of environmental activities and information exchange hitherto scattered among diverse organizations.

Until recently, there were no legal bodies established in the regions with full responsibilities to undertake, supervise and execute environmental protection activities. Recently, however, offices legally mandated for environmental issues have been established and have commenced performing their duties in Addis Ababa, Afar, Oromia, and Amhara regions.

At the Federal and Regional levels, there are several institutions engaged in natural resources protection, development and research. The following are the major ones:

- Ministry of Rural Development
- Ministry/Bureaux of Agriculture
- Ethiopian Wildlife Development and Protection Organization
- The Ethiopian Agricultural Research Organization as well as agricultural research institution in some regions;
- Ministry of Water Resources and regional Water and Energy Bureaus;
- Institute of Biodiversity Conservation and research;
- Ministry of Mines;
- Ethiopian Science and Technology Commission;
- Ministry of Labour and Social Affairs and regional Labour and Social Affairs Bureaux;
- Disaster Prevention and Preparedness Commission and regional Disaster Prevention and Preparedness Bureaux; and
- Rural Energy Development Promotion Centre

In addition, there are quite a number of non-governmental organizations, civil society institutions and trade associations that are involved in environmental protection, conservation and related activities.

#### 4.3.1.2 National Institutions in the Lower Part of the Sub Basins (Sudan)

In recognition of the importance of environmental protection for the sustainable development of Sudan, as well as for the fulfilment of the various United Nations global environmental commitments, the government in 1992 established the Higher Council for Environment and Natural Resources (HCENR) as the central government organ co-ordinating efforts for sustainable development, use of natural resources and environmental protection. The Council includes a number of relevant ministries and places special emphasis on addressing acute degradation, resource depletion, and chronic pollution.

A parliamentary committee on environment and natural resources was also established in 1992. In 1995, the Government also created the Ministry of Environment and Tourism, now Ministry of Environment and Physical Development (MOEPD) to oversee overall environmental management and integrate environmental protection into national development strategies.

**The Higher Council for Environment and Natural Resources (HCENR)**
In accordance with international environmental norms and practices and as a result of the United Nations Conference on Environment and Development (UNCED) held in Rio De Janeiro in June 1992, the Government of Sudan passed, in 1992, an Act that provided for the setting up of the HCENR under the chairmanship and supervision of the Prime Minister, in order to make an effective policies, laws, plans and institution to combat problems of natural resources depletion and degradation of the environment in Sudan.

The mandate of the HCENR as stated in the Environment Protection Act 2001 includes interalia**:** Formulation of general policies for Natural Resources, inventories and development to ensure the appropriate management of the resources and their conservation and sustainable use, develop in co-operation with other government authorities strategies to encourage environmentally sound and sustainable activities; and initiate measures for the co-ordination and enforcement of environmental protection legislation.

The HCENR is chaired by the Minister of the Environment and Physical Development. The HCENR discharges its functions by a General Secretariat. With the following mandate:

- Draft general policies for Natural Resources Inventories and Development to ensure the appropriate management of the resources and their conservation and sustainable use;
- Environment conservation in coordination with the appropriate authorities in the States;
- Coordinate the work of the Council Branches and all efforts in natural resources inventories and conservation and efforts for the sustainable development of the resources, monitor changes in the natural resources; specify areas subjected to depletion, desertification and pollution and decide on priorities for surveys and studies on natural resources;
- Make long-term plans for rational and balanced use of the natural resources and environment conservation and follow-up the execution of the plan with appropriate authorities.
- Periodically review legislation related to the natural resources and the environment, make sure that Laws are effective and introduce any necessary amendments to improve the Laws;
- Establishment of branches in the different States to help the Council in performing its responsibilities;
- Encourage support and coordinate scientific research in all fields of the environment and natural resources;
- Formulate a federal plan for environmental awareness and rational use of the natural resources and try to incorporate environmental education in school curricula;
- Besides these assignments, HCENR is Sudan's outlet to the international environmental arena. It acts as the technical focal point for most of the environmental the conventions emerged from the Earth Summit in Rio De Janeiro (1992) namely: Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC). In addition to the Convention on Persistent Organic Pollutants (POPs). The crosscutting nature of the environmental issues, which spread over different disciplines, has guided the HCENR to form steering and technical committees so as to bring all the concerned stakeholders together, and playing its coordinative role.

In addition to the HCENR, other government ministries have significant roles and responsibilities in the areas of natural resource management, land use planning, and socio-economic development, including:

- The Ministries of Agriculture and Forests;
- Irrigation and Water Resources;
- Ministry of Finance
- Technology and Scientific Research;
- Industry and Commerce;

- Energy and Mining
- National Council for Strategic Planning
- Ministry of Health;
- National Meteorological Authority
- Ministry of Culture and Information; and
- The General Directorate of Public Corporation for Investment

The Ministry of Agriculture and Forests is responsible for agricultural development and natural resources planning and policies, and the National Drought and Desertification Control Unit (NDDCU) in this Ministry has been designated as the national focal point (NFP) to the UNCCD.

- Moreover, several national NGOs in Sudan have formed a network called the Network Committee for Combating Desertification (NCCD), NDDCU and NCCD worked in close collaboration throughout the NAP process.;
- The Government of Sudan has also established the Forest National Corporation (FNC) in 1989, to replace the old Forest Administration (that was established in 1902) to be responsible for the protection and management of forest resources in the country. The FNC is a semi-autonomous corporate body that is attached to the Ministry of Agriculture and Forests. It has a Board of Directors constituted by the Council of Ministers and 10 representatives from related institutions. As such, the FNC is entrusted with the role of protection and conservation of forest resources;
- The Ministry of National Industry is responsible for formulating industrial policies, strategies and programmes that fall within overall national objectives. The Ministry can orient the activities of many industrial activities that are directly related to the Biodiversity, Climate Change and Desertification issues, as the industrial sector is an important user of natural resources;
- The Ministry of Irrigation and Water Resources is responsible for setting national water resources policies, strategies and plans, development of water resources to meet the needs, monitoring of ground water basins, and forging cooperation between the Nile basin countries. It also, contributes to the environmentally sound socio-economic development such as in big irrigated agriculture schemes.

**Wildlife Conservation General Administration (WCGA)**
Established in 1902 by the colonial authorities, WCGA was part of the Game and Fisheries Department of the Ministry of Animal Resources. Today, it is administratively accountable to the Ministry of Interior while technically it is accountable to the Ministry of Environment and Tourism.

The WCGA is entrusted with the conservation of wildlife in the Sudan. Wildlife includes also ecosystems and habitats where species are living. WCGA is also entrusted with the task of establishment and management of protected areas in Sudan. Among its main responsibilities are:

- Sustainable management and utilization of wildlife resources in the country.
- Origination of hunting (issuing licenses and setting by limits)
- Cropping of wildlife, trade in wildlife parts and live animals.
- Establishment of zoological gardens for wildlife public education.
- Control of wildlife damaging problems
- Management of marine national parks and protected areas

WCGA is the focal point for CITES (Convention on International Trade in Threatened and Endangered Species (includes botanical or animal species.) as well as for RAMSAR Convention for the protection of wetland.

The Wildlife Research Centre (WRC) is a part of the Animal Resources Research Corporation. There are no official links between the WCGA and WRC. Research recommendations are not implemented, and the WCGA major approach to wildlife conservation is policing and licensing with no efforts in the area of involving the people in participatory wildlife management or applying scientific wildlife management practices (NBSAP, 2001). Moreover, the WCGA lacks official link with the Fisheries Administration, Fisheries Research that is also under the Ministry of Animal Resource.

**Institute of Environmental Studies (IES), University of Khartoum**

The institute of Environmental Studies (IES) was formally established in 1979, although it was created in 1972 following United Nations Conference on Human Environment in 1972 and subsequent call by the Arab League Educational Cultural and Scientific Organization, (ALECSO) that universities should respond to environmental problems and challenges. Since then, the IES (the first in Africa and the Middle East) has pursued a program which blends a) post-graduate education in environmental studies b) short-term training in natural resources c) research and consultancies in project design, environmental impact assessment and education.

IES executes projects funded by international organization e.g. i) Dry Land Husbandry project (OSSREA and EPOS) ii) Environment Impact Assessment projects (UNEP, UNICEF, US-AID, CPECC UNSO) and iii) Acted as coordinators between Research Institutions and NGOs (Ford Foundation). Project proposals are coordinated through the IES pertaining to the field of coastal zone , arid lands, wetlands meteorology and urban planning. IES qualifies teaching assistants and lecturers to obtain MSc. and PhD degrees in environmental sciences.

**Non-Government Organizations**

Organized forms of NGOs have become well known after 1975 (Mohamed, 1999). Many registered NGOs are actively working on different fields of the environment and rural development. Also there are some networks for coordination between NGOs e.g. the NGOs National Coordination Committee on Desertification (NCCD). The following are some examples of Sudanese NGOs working on environment-related work.

**Sudanese Environmental Conservation Society (SECS)**

SECS is considered the most active NGO group in promotion of environmental awareness and lobbying for better environmental policies and actions. It does so by initiating and supporting small projects with grassroots involvement designed to improve living conditions and well being (Mohamed, 1999). Examples of these projects include tree planting, waste management and awareness raising. SECS have more than 80 branches distributed all over Sudan, with more than 6,000 members. The main objectives of SECS include:

- Conservation of the environment and mitigation of any action that may lead to environmental degradation;
- Dissemination of environmental awareness;
- Cooperation with the government in law enforcement for environmental conservation;
- Strengthening the links with the local, national, regional and international institutions endeavouring to conserve the environment; and
- Encouraging scientific research and studies aiming at the conservation of the environment, in addition to writing of the natural history of the Sudan. (ElNour *et al* 2001)

**Sudanese Social Forestry Society (SSFS)**

SSFS is a charitable NGO with dedicated memberships who believe in social and multiple benefits of the forest. SSFS seeks promotion of concepts and practices of people involvement and social forestry in Sudan. The main objectives of SSFS are: -

- To promote the concept and practices of social forestry, through networking and linkages between social forestry and extension units in Sudan;
- Enhance the standards of awareness of the community participation in social forestry;
- Encourage the scientific applied research in social forestry and promote the output of the same among the interested persons;
- Assist in the fund raising and appropriate resource funding of the social forestry projects;
- Facilitate and forward the technical consultancies in the field of social forestry projects;
- Cooperate with the concerned bodies, for the development of social forestry;
- Collect, authenticate and publish information regarding the social forestry activities;
- Establish advanced relation with international and national network;
- Preserve the natural forests as a natural heritage.

#### 4.3.1.3 Responsibilities of Institutions Affecting Water Quality and Their Responsibilities in the Main Nile (Egypt)

The institutions involved with water quality management in Egypt are generally line-management ministries with responsibilities in areas that are related to, but not necessarily coincident with, environmental protection. The Ministry of Health and the Ministry of Industry have many other functions, many of which conflict with water quality management. Egypt lacks such a relatively strong central coordinating or managing body, although the Egyptian Environmental Affairs Agency (EEAA) has some of the appropriate rules (coordination, studies and evaluation).

Following are discussions of the institutions with major roles in water quality management.

**Minister of Water Resources and Irrigation (MWRI)**

The MWRI is formulating the national water policy to face the problem of water scarcity and water quality deterioration. The overall policy’s objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country. Under law No. 12 of 1984, MWRI retains the overall responsibility for the management of all water resources, including available surface water resources of the Nile system, irrigation water, drainage water and groundwater.

The MWRI is the central institution for water quality management. The main instrument for water quality management is Law 48. The MWRI is responsible to provide suitable water to all users but emphasis is put on irrigation. It has been given authority to issue licenses for domestic and industrial discharges. The responsibility to monitor compliance to these licenses through the analyses of discharges has been delegated to MOHP.

The National Water Research Centre (NWRC) supports the MWRI in its management. Within the NWRC, three institutes are focusing on the Nile, the irrigation and drainage canals and groundwater (NRI, DRI, RIGW). NWRC maintains a national water quality-monitoring network and contracts portions of the monitoring activity to these institutes. NWRC also operates a database where all MWRI water quality data is consolidated. NWRC also operates a modern, well-equipped water quality laboratory.

**Egyptian Environmental Affairs Agency (EEAA)**

The central organization for environmental protection is the EEAA. This agency has an advisory task to the Prime Minister and has prepared the National Environmental Action Plan of Egypt 2002/17 (2002). The Minister of State for Environment heads the agency. According to Law 4, it has the enforcing authority with respect to environmental pollution except for fresh water resources. Through Law 48, the MWRI remains the enforcing authority for inland waterways.

The EEAA is establishing an Egyptian environmental information system (EEIS) to give shape to its role as coordinator of environmental monitoring. Moreover, staff is being prepared to enforce environmental impact assessment (EIA). Major industries have been visited in view of their non-compliance with respect to wastewater treatment. Compliance Action Plans (CAP’s) are being agreed upon to obtain a grace period for compliance. Additionally EEAA is monitoring waste from Nile ships and is responsible for coastal water monitoring. In cooperation with the MWRI, an action plan was implemented to reduce industrial pollution of the Nile.

**Ministry of Health and Population (MOHP)**

The MOHP is the main organization charged with safeguarding drinking water quality and is responsible for public health in general. Within the framework of Law 48/1982, this Ministry is involved in standard setting and compliance monitoring of wastewater discharges. The Environmental Health Department (EHD) is responsible for monitoring with respect to potable water resources (Nile River and canals). The MOHP samples and analyses all intakes and treated outflows of drinking water treatment plants. Also water from drinking water production wells is monitored. In case of non-compliance of drinking water quality, especially with respect to bacterial contamination, MOHP takes action.

Within the framework of Law 48 MOHP samples and analyses drain waters to be mixed with irrigation waters, industrial and domestic wastewater treatment plant effluents and wastes discharged from river vessels. In case of non-compliance of discharges, the MWRI generally takes action upon notification from the MOHP.

**Ministry of Housing, Utilities and New Communities (MHUNC)**
Within the Ministry of Housing, Utilities and New Communities, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) has the responsibility for planning, design and construction of municipal drinking water purification plants, distribution systems, sewage collection systems, and municipal wastewater treatment plants. Once the facilities have been installed, NOPWASD organizes training and then transfers the responsibilities for operation and maintenance to the regional or local authorities.

**Ministry of Agriculture and Land Reclamation (MALR)**
MALR develops policies related to cropping patterns and farm production. Moreover, they are in charge of water distribution at field level and reclamation of new agricultural land. With respect to water quality management issues, their policies on the use and subsidy reduction of fertilizers and pesticides are important. In addition, MALR is responsible for fisheries and fish farms (aquaculture).

The Soil, Water and Environment Research Institute is part of the MALR and is responsible for research on many subjects such as water and soil quality studies on pollution, bioconversion of agricultural wastes, reuse of sewage wastewater for irrigation, saline and saline-alkaline soils, fertilizer and pesticide use and effects.

**Ministry of Industry (MOI)**
The government has owned the majority of industries in Egypt for many decades. Within the MOI, the General Organization for Industrialization (GOFI) manages the publicly owned facilities. The present government is in the process of privatization of industries. At this moment GOFI still manages approximately 300 industrial facilities. MOI maintains a register of all industries in Egypt including design data related to processes used and quantities of water taken in and discharged by each facility.

**Ministry of Higher Education and Scientific Research (MHESR)**
Two of the research institutes of the Ministry of Higher Education and Scientific Research (MHESR), namely the National Research Centre (NRC) and the National Institute for Oceanography and Fisheries (NIOF), collect samples for specific research projects. Both institutes have modern well-equipped water quality laboratories.

**Ministry of Interior**
The Ministry of Interior, Egypt's national police force, has for some time maintained the Inland Water Police, a special police force for enforcement of Law 48 and protection of the environment in general. The Inland Water Police provides guidance to citizens and takes enforcement actions for violations of environmental laws. Law 4/1994 provides additional authority for this environmental police force, specifying that the MOW shall form a police force specialized in environmental protection within the Ministry and in its Security Departments in the governorates. (Article 65 of the Executive Regulations).

It is worth mentioning that the Egyptian legislation has been concerned with the environmental resources since long time; and has organized the human activities that affect the environment. However, for political and economic reasons it became difficult for the Egyptian legislator to apply these laws and for the citizens to abide with these regulations.

**Non-Governmental Organizations**
Non-Governmental Organizations (NGOs) in Egypt have an important role to play in contributing to the country's social, economic, and democratic development. In this respect, the Egyptian government has been encouraging and supporting the establishment of various NGOs, especially those working in the fields of environmental awareness and protection. Currently, there are more than 2,000 environmental NGOs in Egypt, some of them are more active than others, but collectively they play an indispensable role in raising public awareness towards environmental issues, and in conducting environmental protection and conservation activities

### 4.3.2 International Agreements and their Implementation

#### 4.3.2.1 Upper Part of the Sub Basins (Ethiopia)

Ethiopia has adopted and ratified several international conventions and agreements related to the environment. The following are the major ones.

Convention on Biological Diversity

The Convention on Biological Diversity has three goals:

- The conservation of biodiversity;
- The sustainable use of the components of biodiversity; and
- The fair and equitable sharing of the benefits arising from the use of genetic resources.

The Convention was ratified by Ethiopia by Proclamation 98/94, on May 31, 1994.

Various activities are being carried out towards the implementation of this convention. The following are some of the exemplary activities:

- A project entitled, *"A Dynamic Farmers Approach to the Conservation of Plant Genetic Resources"* has been implemented using financial support from Global Environmental Facility (GEF);
- A National Biodiversity Protection and Research Policy has been prepared;
- Prior to 1998, the Institute of Biodiversity whose responsibility was to sample and conserve the country's plant genetic resources has now transformed itself into the Institute of Biodiversity Conservation and Research with additional duties regarding animal life and micro-organisms;
- Places for the conservation of coffee species has been identified in various parts of the country;

- A Forest Genetic Resources Conservation Project is being implemented. This project commenced in 1999 with financial support from GTZ. Its objectives include development of national forest genetic resources research strategy, registration of woody biomass, conducting socio-economic surveys in natural forest areas, establishing forest gene banks, compiling data on indigenous trees and shrubs, awareness creation and institutional capacity building;
- A Project for the Conservation and Sustainable use of Medicinal Plants is being implemented. The objective of this project is to promote the expansion of medicinal plants through conservation in internationally recognized areas by encouraging their sustainable use. The Institute of Biodiversity Conservation and Research is implementing the project with financial support from the Global Environmental Facility. Through this project, efforts are being made to identify and gazette areas for conservation and management of medicinal plants, undertake detailed socio-economic and biological survey, as well as draw up resource protection and management alternatives and guidelines;
- *National Biodiversity Strategy and Programme: -* The project aims at developing a national biodiversity strategy and programme in collaboration with the relevant federal and regional institutions;
- Wildlife Protection Support Programme: - This programme is being implemented with financial support from several international donors and the details of its activities are as follows:
    - Establishment of an endowment fund, rehabilitation of infrastructure, undertaking community and tourism development in 6 national parks as well as rehabilitating and enhancing the management of protected areas of prime importance is in progress with assistance from UNDP. The Ethiopian Wildlife Conservation and Development Organization with technical support from the World Wildlife Fund, East African Regional Programme is implementing this project;
    - Rehabilitation of three national parks (Omo, Mago and Nech Sar) is underway with financial support from the European Union;
    - A Programme for the conservation of priority forests is being undertaken with financial support from the Dutch Government; and

- An effort is being made to improve household security for pastoralists and undertake conservation and protection activities in the Awash National Park.

- A Project for the Conservation and Sustainable Use of Biodiversity in the East African Rift Valley Lakes is being considered for implementation by Ethiopia, Kenya and Tanzania with financial support from Global Environmental Facility. The objective of the project is to strengthen and enhance the conservation and sustainable use of the biodiversity resources in these lakes. The project particularly aims at developing and strengthening appropriate systems for the protection and conservation of threatened ecosystems; and

- A Biodiversity Protection and Conservation Support Project in important bird areas is being implemented. The project has been operational since 1999 by the Ethiopian Wildlife Conservation and Development Organization with financial support from the Global Environmental Facility.

**The United Nations Convention to Combat Desertification (CCD)**
The objective of the Convention is to combat desertification and mitigate the effects of droughts in countries experiencing serious drought and/or desertification, particularly in Africa. Ethiopia has ratified the Convention by Proclamation No. 80/1997.

To implement the Convention, the following activities are being carried out with the coordination of the Environmental Protection Authority and financial support provided by various donor agencies.

- Completion of the drafting of a national programme for combating and controlling desertification;
- Providing some capacity building support and implementing awareness raising programmes in the regions;
- Preparation by some of the regions of regional programmes for combating and controlling desertification;
- Using participatory approaches, pilot projects designed to demonstrate for communities how degraded land can be rehabilitated are underway in four regions;
- The drafting of a gender strategy designed to facilitate the incorporation of gender issues into the programme for combating desertification is in the process of preparation; and
- A draft document with respect to the establishment of a fund for combating desertification has been finalized.

**The Vienna Convention for the Protection of the Ozone Layer**
The basic objective of this Convention is to combat the negative impact on the environment and human beings resulting from ozone depleting substances by reducing the amounts released and eventually banning their commercial use through internationally agreed measures. The Montreal Protocol entered into force in 1989 to facilitate the implementation of the Convention.

Ethiopia ratified and became party to the Vienna Convention and the Montreal Protocol in January 1996. The National Meteorological Services Agency has been mandated for the coordination and supervision of implementation of this convention in Ethiopia.

The following activities have so far been conducted towards implementing this convention:

- A programme for controlling ozone-depleting substances in Ethiopia is in place;
- A National Ozone Team has been established under the auspices of the National Meteorological Services Agency;
- A project for the repair and reuse as well as a programme with respect to the handling of CFC-based refrigerators have been developed;
- A draft legislation for the control of substances that deplete the ozone layer has been prepared; and
- Training on awareness creation training has been conducted.

**Framework Convention on Climate Change (FCCC)**
Ethiopia has ratified this Convention by Proclamation No. 97/1994 on May 2/1994. This convention takes into account the fact that climate change has trans-boundary impacts. The basic objective of

this Convention is to provide for agreed limits regarding the release of greenhouse gases into the atmosphere and prevents the occurrence or minimizes the impact of climate change.

The following major activities have been undertaken to implement the Convention at national level:

- Within the National Meteorological Services Agency, a Climate Change and Air Pollution Research Team has been established;
- Major sources of greenhouse gases in the country have been registered. A preliminary research has also been conducted to verify the effect of climatic change on the water flow of the Awash River as well as on wheat production and forest resources;
- Research has been undertaken on the best possible measures to minimize greenhouse gas emissions associated with energy utilization as well as from grazing and livestock production; and
- A National Climate Change Report has been prepared for the first time in the country and submitted to the Secretariat of the Convention.

The Basel Convention
The objective of the Basel Convention is to control and regulate the trans-boundary movement of hazardous waste. The Bamako Convention of 1991 plays a similar role at the level of the African continent.

Ethiopia has ratified the Convention by Proclamation No. 192/2000. At present measure designed to amend the Basel Protocol is in progress. In addition, activities related to prior informed consent are being carried out. Furthermore, to implement the Convention within the country, draft policies and legislation have been prepared and submitted to the government.

The Stockholm Convention
In the year 2002, Ethiopia fully accepted and ratified the Stockholm Convention designed to ban the use *of persistent organic pollutants (POPs).* The Environmental Protection Authority has the full mandate to implement the Convention at the national level. A project to develop an appropriate system for the realization of the objectives of the Convention in Ethiopia is in progress.

The Rotterdam Convention
This Convention relates to prior informed consent in the context of international trade in specific hazardous chemicals and pesticides. The Environmental Authority is the organ responsible for the domestic implementation of this convention, which has been ratified by Ethiopia in 2003. The Environmental Protection Authority is preparing a framework for its implementation.

International Convention on Trade in Endangered Species, Fauna and Flora
The objectives of the Convention are:

- To control international trade in endangered species
- To ensure that international trade in non-endangered species is carried out in a manner which ensures stable markets and economic benefits for the exporting countries as well as to control and regulate illegal trade in such non-endangered species, fossils and/or their derivatives.

Ethiopia has ratified the Convention. The mandate to implement the Convention at the Federal level is bestowed upon the Ethiopian Wildlife Protection and Development Organization.

#### 4.3.2.1 National Strategies in Response to Multilateral Environmental Agreements in the Lower Part of the three Sub Basins (Sudan)

**Agenda 21 Project**

In response to Agenda 21 (Rio Earth Summit 1992), a project was implemented in Sudan to build capacities needed to meet the challenges of the Twenty First Century. The project helped in building capacities of government institutions, private sector and non-governmental organizations to implement sustainable development projects. The project played an important catalytic role in promoting community level environmental protection. The project succeeded in building the capacities of Two State Environmental Councils and in the preparation of Environmental Action

Plans for 4 States. This provides for a ground level identification of National Agenda 21 and the process of formulation of a National Sustainable Development Strategy.

**National Biodiversity Strategy and Action Plan (NBSAP)**
Since 1995, the Sudan government has become party to the Convention on Biological Diversity (CBD). The Government of the Sudan developed with GEF support and technical assistance from World Conservation Union (IUCN) its first National Biodiversity Strategy and Action Plan in May 2000 and its first Country Study on Biological Diversity in April 2001. The NBSAP outlines strategies, priorities and actions for biodiversity conservation and protection of natural ecosystems

**National Implementation Strategy for the UN Framework Convention on Climate Change**
In 1992, the government of Sudan signed the United Nations Framework Convention on Climate Change (UNFCCC), and ratification took place in 1993. An enabling activity for climate change funded by GEF/UNDP was implemented by the HCENR. The project conducted many activities including training, GHG inventory, vulnerability and adaptation assessment, and mitigation analysis, in addition to an intensive awareness program. As part of complying with its commitments towards the Climate Change convention, Sudan has completed its National Communication under the UNFCCC in February 2003.

**Assessment of Impacts and Adaptation to Climate Change (AIACC-AF14)**
To fill the gaps and shortcomings of the vulnerability and adaptation assessment to climate change, a three-year project is implemented as part of the "Global Assessment of Impacts of and Adaptation to Climate Change (AIACC)" through GEF/UNEP. This project aims at enhancing the scientific and technical information, assessing the impact of climate change and designing cost-effective response measures which are needed to formulate national policy options.

**National Action Plan (NAP) to Combat Desertification**
In November 1995, Sudan ratified the United Nations Convention to Combat Desertification (UNCCD). The National Drought and Desertification Control Unit (NDDCU) has been designated as the national focal point to the UNCCD. The NDDCU identified the States that are affected by the desertification process. As part of its commitments under this convention, a National Action Programme (NAP) has been prepared in April 2002. The challenges which face the implementation of NAP in Sudan include lack of a coherent national land use plan, dependence of household energy on forests products, expansion of mechanized rain fed agriculture and the civil war.

**Persistent Organic Pollutants (POPs)**
The POPs Enabling activities will allow the Sudan to meet its obligations under the Stockholm Convention on POPs and create sustainable capacity and ownership in Sudan to meet these obligations.

Moreover, Sudan is also involved in key GEF funded regional initiatives under the international waters operational programmes and is an active player in all these initiatives which include the Kijani Initiative, the project for the Protection of Key "Bottleneck" Sites for Soaring Migratory Birds in the Rift Valley and Red Sea Flyway, the Nile Trans-boundary Environmental Action Project, the Strategic Action Programme for the Red Sea and Gulf of Aden (PERSGA) and the project for the Removal of Barriers to the Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies. In the context of these regional initiatives, several capacity building activities are expected to benefit participating countries and accordingly the Sudan will be able to enhance its capacities related to the global conventions through exchange of experience and transfer of knowledge.

**Biodiversity Conventions and Agreements**
Since 1936, Egypt is party to a large number of regional and international conventions, treaties and agreements dealing with the conservation of nature in general and biodiversity in particular. The following list is extracted from the latest edition of UNEP's Register of International Treaties and Other Agreements in the Field of the Environment 1996:

- Convention Relative to the preservation of Fauna and Flora in their natural state. London, 1933 (ratified in 1936);
- Agreement for the Establishment of a General Fisheries Council for the Mediterranean. Rome, 1951;
- International Plant Protection Convention. Rome, 1953;
- International Convention for the Prevention of Pollution of the Sea by Oil. London, 1963;
- Phyto-sanitary Convention for Africa. Kinshasa, 1968;
- African Convention on the Conservation of Nature and Natural Resources. Algeria, 1968. (Ratified in 1972);
- Convention for the Protection of the Mediterranean Sea Against Pollution. Barcelona, 1976 (ratified in 1978);
- Convention on International Trade in Endangered Species of Wild Fauna and Flora. Washington, 1978;
- International Convention for Regulation of Whaling. Washington, 1981 (ratified in 1989);
- Convention on the Conservation of Migratory Species of Wild Animals. Bonn, 1979 (ratified in 1982);
- United Nations Convention on the Law of the Sea. Montego Bay, Jamaica, 1982 (ratified in 1983);
- Protocol Concerning Mediterranean Specially Protected Areas, Geneva, 1983 (ratified in 1986);
- Convention on Wetlands of International Importance especially as Waterfowl habitat. Ramsar, Iran, 1971 (1975), (ratified in 1988);
- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment. Jeddah, 1990;
- Convention on Biological Diversity, Rio de Janeiro, 1992 (ratified in 1994);
- Agreement for the Establishment of the Near East Plant Protection Organization. Rabat, Morocco, 1993 (ratified in 1995);
- International Tropical Timber Agreement. Geneva, 1994 (ratified in 1996); and
- Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean. Barcelona, 1995.

## 4.4 Other Environmental Issues

### 4.4.1 Environmental Programmes and Projects in the Upper Part of the Three Sub Basins (Ethiopia)

The following projects either have been already implemented or are in the process of implementation:

- Project for the Control and Disposal of Expired Pesticides;
- Project for the Preparation of a National Chemical Handling and Registration guideline;
- The Ecologically Sustainable Industrial Development Project;
- The National Cleaner Production Centre Project;
- The Amhara Region Sustainable Development Project;
- The Energy and Woody Biomass Survey Project;
- The Addis Ababa Industrial Zone Cost Benefit Analysis Project;
- The Tannery Pollution Control Project;
- The Project for the Generation of Employment for Women Fuel-wood Carriers;
- The Project for the Environmental Auditing of 10 Factories; and
- The Federal and Regional Conservation Strategies.

#### 4.4.1.1 Environmental Information System (Ethiopia)

Environmental information is very crucial for decision making on environmental issues and for the creation of awareness among various bodies. In view of the pivotal role that information plays, the Ethiopian Environmental Policy has incorporated it as one of the cross-sectoral policy issues.

At present, it is difficult to say that there is an efficient and consistent environmental information system in the country. In the past, since different institutions collected environmental data from diverse sources at different times and for various purposes, they were not compatible and lacked consistency in time and space. Data captured earlier are scattered all over the place and there is fear that no one could locate where exactly they are. As a result, one could say that environmental control and monitoring activities are not conducted appropriately. Since the data collected at various levels are not properly kept centrally or otherwise, it is possible to say that they are not in a position to provide the necessary benefits in relation to the cost incurred to capture them.

Much effort is being made at present, in the area of the collection and storage of environmental data. Project work to establish a metadata environmental and natural resources database is in progress under the auspices of the Ministry of Water Resources with financial support from the Dutch Government. This project aims to create one central national metadata base in order to ensure consistency of data, avoid duplication of work among bodies engaged in this kind of activity and minimize financial and manpower wastages.
What is more, the Environmental Protection Authority has also started some initiatives in this area by setting up an environmental information centre.

#### 4.4.2 Environmental Education/Knowledge in Main Nile (Egypt)

Education and awareness are essential tools in highlighting the importance of environmental protection. In this respect, there have been recent initiatives aimed at enhancing and developing environmentally literate citizens who share a concern for environmental protection issues. This could be realized through introducing environmental education and training programs on both formal and informal levels of education.

Formal education is that directed at schools and universities, while informal education is directed to all strata of society, at all ages and cultural levels. Formal education has been carried out at each educational stage such as primary schools, preparatory schools, and universities.

Non-formal education is all-important to environmental awareness, since it targets a wide range of groups and includes all strata of society. Mass media and newspapers play a very important role in effective environmental education programs of this type.

EEAA, realizing the importance of raising the public's environmental awareness, is providing continuous support to environmental training and awareness activities and initiatives. This is reflected in the protocol between the Ministries of Education and Environment signed in 1999. The protocol addresses the integration of environmental dimensions in the formal curricula, the development of teacher-training materials, and the design of informal environmental training programs. A collaborative partnership between EEAA and the various channels of mass media has been developed. Within this framework, EEAA has sponsored several daily and weekly environmental radio and TV programs in addition to the environmental sections in major newspapers.

## 5. ENVIRONMENTAL STATUS AND THREATS

### 5.1 Environmental Degradation and Threats in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

#### 5.1.1 Land Degradation and Soil Erosion in the Upper Part of the Sub Basins (Ethiopia)

In the Abbay sub basin, extensive land degradation has occurred as a result of deforestation and inappropriate agricultural practice. This in turn has resulted in both soil erosion and loss of fertility to a large area of the basin especially in the highlands (FAO, 1986). The Same study has showed that annual loss of some 681.5 Mt/year out of which 130Mt/year is carried out of the basin and erosion is resulting in a 2-3 %annual decline in crop yield.

The eastern area of the basin, with a combination of steep slope, erodible soils and highly erosive rainfall, are areas of soil erosion hazards. Similarly, the trans-boundary environmental analysis has indicated that the highlands of Abbay sub basin are characterized by land degradation (severe deforestation, soil erosion, moderate to severe riverbank and lakeshore degradation) and water quality degradation (pollution, siltation)

According to the Nile river basin trans-boundary environmental analysis (2001), environmental threats observed in the Baro-Akobo sub basin include, land degradation (deforestation in the high lands, soil erosion) water quality degradation (moderate water pollution-point or not point source, sanitation, water born diseases and environmental health).

Land degradation occurs in various forms throughout the Baro-Akobo sub basin: soil erosion by water, chemical degradation, (leaching of bases), physical degradation (loss of porosity), and biological degradation (loss of humus)

The most extensive and pervasive environmental problem in the Tekeze sub basin in general and in the highlands of the basin in particular, is land degradation and soil erosion. Awareness of erosion as an environmental issue exists only since a few decades. Of the natural conditions, two general features have caused high erosion hazards since ages: the erosive character of the rainfall pattern and the predominantly steep relief in most of the study area. Erosion hazard turns into actual erosion if the protective vegetation cover is depleted.

In the Tekeze sub basin, water erosion in the form of sheet, rill and gully erosion is the most intensive and widespread form of land degradation. Of the water erosion phenomena, sheet erosion or interrill erosion, including soil transport by rain splash, is probably contributing most of the total impact of erosion. Rill and gully erosion are more spectacular because more evident features are formed during much shorter periods. Stream bank erosion is one of the striking features throughout the basin.

In Ethiopia, up to 400 tons of fertile soil/hectare is lost annually from lands devoid of vegetative cover as well as from lands where no soil conservation has been carried out. The soil lost annually is from the farmlands, which make up 13 % of the total area. This kind of erosion is common at altitudes between 1,700 to 2, 600 meter above sea level and where extensive farming activities are carried out.

In the Baro-Akobo sub basin, for example, soil loss due to runoff, loss of forest cover, etc., are increasing and the risk and consequences of soil erosion have been expanded. Soil loss due to removal of vegetation cover is an ever-present condition in the upland zones of the basin. The following table shows soil loss in the Baro-Akobo sub bain.

Table 23: Soil loss in the Baro-Akobo sub basin

| Cover | Slope (%) | Runoff (%) | Soil Loss (T/Ha/Y$^{-1}$) |
|---|---|---|---|
| Grass, percent | 36 | 6.9 | 0.026 |
| Grass, 20 percent | 20 | 29.0 | 12.0 |
| Forest | 7.15 | 2.4 | 0.24 |
| Cirrus + mulch | 7 | 2.6 | 4.3 |
| Citrus | 7 | 9.2 | 18.9 |
| Row crop + mulch | 7 | 39 | 89.4 |
| Fallow + Weed Grow | 7 | - | 5.3 |

*Source: Ministry of Water Resource (Ethiopia)*

On the other hand, in the Tekeze sub basin, soil degradation in terms of fertility loss and erosion starts gradually, but decreased productivity has been compensated by the expansion of the cultivated area. In general, population increases during the past 50 to 100 years have entailed the dramatic increases in land degradation and erosion rates, but around the old habitation centres, this must have started earlier. Limits of natural regeneration of resources were passed when increasing demands for land has forced peasants to expand cultivation onto steeper land being much more susceptible to erosion. Increasing demand for fuel and timber has caused large-scale deforestation.

### 5.1.2 Deforestation and Loss of Biodiversity

No area of undisturbed forest remains in the Abbay sub basin and only 1% (2300 km$^2$) of that disturbed forest remains today. The assessment made by FAO 1n 1984 showed that at that time, 4% (8,000 km$^2$) of the basin was covered by forest. This represents a conversion of about 475km$^2$ per year.

The main cause of deforestation is the need of a rapidly growing rural population for fuel wood (estimated at about 1.8 $m^3$ /person/year), building materials, and agricultural land, which is also responsible for the conversion of forests.

Similarly, as a result of combined action of civil unrest, land conversion to agriculture, fuel wood harvesting, burning and increase in population of refugees, the Baro-Akobo sub basin is losing large amount of forest annually.

Deforestation is also a key issue in the Tekeze sub basin. Population pressure and unsustainable agricultural practices have resulted in distraction of forests for use for fuel wood and conversion to cultivation. This leads to erosion and soil depletion, which in turn leads farmers to deforest and cultivate further areas. Deforestation of steep slopes has led to severe erosion and loss of soil fertility.

The fuel demand in the Tekeze sub basin, using a developed model, is given below. The fuel demand, expressed in Peta Joules (PJ) is given by fuel type for the year 1995, 2000, 2010, and 2045.

Table 24: Fuel demand by fuel type

| **Fuel** | **1995** | **2000** | **2010** | **2025** | **2045** |
|---|---|---|---|---|---|
| Electricity | 0.26 | 0.40 | 0.97 | 3.04 | 7.66 |
| Kerosine | 0.41 | 0.40 | 3.75 | 6.41 | 9.89 |
| Diesel | 2.84 | 2.69 | 6.56 | 15.49 | 50.94 |
| LPG | 0.00 | 3.77 | 0.17 | 0.82 | 2.13 |
| Gasoline | 0.24 | 0.02 | 0.66 | 1.97 | 7..03 |
| Firewood | 48.48 | 0.34 | 45.16 | 57.80 | 86.53 |
| Wax | 0.02 | 41.65 | 0.00 | 0.00 | 0.00 |
| Charcoal | 8.08 | 0.00 | 19.30 | 24.53 | 34.38 |
| Dung | 12.42 | 19.77 | 9.07 | 11.33 | 15.55 |
| Agri Residues | 3.69 | 8.42 | 2.23 | 2.83 | 3.80 |
| Batteries | 0.00 | 2.06 | 0.03 | 0.11 | 0.16 |
| Total | 76.54 | 0.00 | 79.12 | 124.33 | 218.13 |

*Source: Ministry of Water Resources Development*

From the table, the following could be noted. The fuel wood, agricultural residues and dung demand has decreased between 1995 and 2000 as a result of expected improvements in the energy efficiency of the cooking devices (Enjera and charcoal stoves) and through fuel switching. After the year 2000, however, the demand will increase again as a result of population growth. Charcoal demand shows somewhat a similar trend.

The other problem is encroachment and destruction of wildlife habitats in the Simien Mountains, Shiraro-Qafta Wildlife reserve and wildlife habitats around Humera. Encroachment of Simien Mountains is likely to accelerate than ever due to the construction of road through the conservation area. The current gold prospecting activities around Sheraro-Qafta may identify suitable extraction sites in or close to the reserve. Labour camps are likely to fell trees for fuel and hunt game for food. Deforestation to make way for irrigation is being carried out by numerous small farmers around the Humera area forcing elephants and other large mammals to migrate to other areas.

Ethiopia occupies a unique position in the world with regard to plant and animal diversity. There is a high level of endemism within the country with 99 endemic animals and about 800 endemic plants. However, the ability of Ethiopia to maintain this high degree of inherent biodiversity is now under threat as human use moves insatiably into the few remaining areas. EWNHS (1996) has identified that, of the 16 endemic bird species within Ethiopia, half of these are still found in Abbay sub basin, of these two (the Ankober Serin and Harwood's Francolin) are categorized as Vulnerable in the list of globally threatened species. Wild habitats are shrinking and apart from those savannah woodland areas in the northwest part of the basin, or those areas that have tsetse fly infestation few habitats remain intact. Urgent action is needed to address this problem of shrinking habitat and biodiversity loss before extinctions occur.

### 5.1.3 Population Pressure and Conflicts on Resources

In the Tekeze sub basin, food production, livestock feed and fuel requirements put competing demands on scarce and vegetation resources. The Tekeze sub basin has been a process of gradual degradation of land and vegetation under population pressure and inadequate management of natural resources. An analysis of scarcity and degradation of resources in the studied 42 Peasant Associations (Pas) showed that pressure on resource is strong or critical in 31 PAs and low or moderate in 11 PAs. Most of the later are situated in the western lowlands of the basin.

### 5.1.4 Pollution and Environmental Health Threats

Of the water related diseases in the Abbay sub basin, the major concern is malaria, which is increasing, difficult to control, and has potential to infect a very large population in epidemic outbreaks. The other water related diseases in the area are Schistosomiasis, Typhoid, Diarrhea, Helminthiasis, Leshimaniasis, and Onchocerchiasis.

Regarding Tekeze sub basin, four major vector-borne diseases, notably malaria, intestinal schistosomiasis, visceral leishmaniasis (VL) and onchocerciasis are confirmed as being endemic and pose a major challenge to socio-economic development effort in the area. The incidence of malaria and schistosomiasis will increase in areas of ongoing micro-dam construction. Most major settlements in the basin have non-extent or inadequate drinking water supply systems. Sanitation is also inadequate, piped drinking water should be boiled for use.

Mekele already has a water quality problem due to the chemical composition of the aquifer rocks. At present Lalibela has severe water shortage with daily water cuts. The existing residential areas have few latrines. People defecate on the hills surrounding the town. This has resulted in the pollution of the land underneath the rock-hewn churches in the valley. Sample taken from the churches foundations show evidence of erosion with urine concentrations.

The following are some of the causes of pollution and environmental health threats in the Tekeze sub basin.

**Pests and Weeds:** Regular crop yield loss caused by various pests such as weeds, diseases, insects, rodents and birds are common. The existing weed control measures are limited to hand weeding, commonly performed quite late after crop emergence. Farmers do not use herbicides. Single weeding is the common practice in all cereals, except Teff, which gets more attention. Diseases such as rust, smut, scald and blotch are reported to cause damage to various crops, virtually no measures are taken by peasant farmers to control these diseases. Insects are the major pests in the area. They cause a substantial damage on different crops. However, only a very limited number of farmers use Malathion in order to control insect pests like armyworm and grasshopers. Due to inadequate and/or delayed supply and poor technical know-how of farmers, the present efficiency of pesticide use by peasant farmers is quite low.

**Loss and decay of cultural heritage sites:** As the number of visitors to Lalibela increases due to the opening of the airstrip and new road, the pressure on the already non-extent sanitation grows. The foundations of the rock-hewn churches are being eroded by urine. Historic relics are largely unprotected from visiting tourists. Some items in Lalibela and other rock-hewn churches and museums in Axum have been stolen. There is a risk that current proposals for new industries, mines and dam sites may lead to constructions close to cultural heritage sites, possibily causing deterioration.

**Mining:** There are project proposals for exploration activities to be undertaken in the north east of the basin near Hawzen. Similar activities are currently being undertaken in the northwest prospecting area. The environmental impacts of mining will depend on the type of mining, the chemical processes used and the characteristics of the location. In addition, land taken by the mine, potential negative impacts include depletion of water resources due to over extraction, pollution of water and soil, degradation of landscape, subsidence, dust and noise.

**Industrial and agricultural input pollution:** These include air pollution in Mekele from the cement factory, water pollution from the newly constructed Sheba Tannery and the dyeing factories of Tigray.

### 5.1.5 Environmentally Sensitive Areas

The following table lists where these environmentally sensitive areas are located in the Abbay sub basin and the items that need protection.

Table 25: Location of environmentally sensitive areas in the Abbay sub basin

| Type of Area and Name | Location | Features |
|---|---|---|
| *Birds*<br>1. Ankober-Debre Sina Escarpment<br>2. Awi Zone<br>3. Choke mountains<br>4. Jemma and Jara valles<br>5. Bahir Dar and Lake Tana<br>6. Fogera plains<br>7. Guassa (Menze)<br>8. Mid Abbay gorge<br>9. Yegof Forest<br>10. Fincha and Chomen Swamps<br>11. Dabus Swamp | 09$^{0}$36'N/39$^{0}$46E<br>11$^{0}$45'N/37$^{0}$00'E<br>10$^{0}$42'N/37051'E<br>10$^{0}$08'N/38$^{0}$56'E<br>11$^{0}$37'N/37$^{0}$25'E<br>11$^{0}$57'N/37045'E<br>10$^{0}$21'N/39$^{0}$48'E<br>07$^{0}$44'N/12$^{0}$46'E<br>11$^{0}$06'N/39$^{0}$45'E<br>09$^{0}$34'N/37$^{0}$21'E<br>10$^{0}$36'N34$^{0}$54'E | Ankober Serin, Ruppell's Chat<br>Various Habitats, Rouget's Rail, etc<br>Forest; Abyssinian Longclaw<br>Harwood's Francolin, Ruppell's Chat<br>Wetland; Wattland Crane, Gr. Spotted Eag<br>Wetland; Lesser Kestrel etc<br><br>Rouget's Rail, Abyssinian Longclaw<br>Harwood's Francolin<br>Forest; Home to 18 highland biome<br>Wetland; Wettled Crane, Roget's Rail |
| *Wildlife*<br>12. Dinder wildlife area<br>13. Didessa wiledlife area<br>14. Dabus Vally controlled hunting | 11$^{0}$48'N/35$^{0}$24'E<br>08$^{0}$12'N/36$^{0}$36'E<br>10$^{0}$24'N/34$^{0}$54'E | Large animals; need further assessment<br>Large animals, need further assessment<br>EWCO to assess and allocate use |
| *Fish*<br>15. Lake Tana | Lake Tana | Home of 13 isolated Barbus spp.hexaploi |
| *Domestic Animals*<br>16. Fogera plain | 11$^{0}$54'N/37$^{0}$36'E | Home of indigenous Fogera Cattle |
| *Afro-alpine Areas*<br>17. Mt. Guna<br>18. Mt Amba Farit<br>19. Mt Choke | 11$^{0}$42'N/38$^{0}$12'E<br>11$^{0}$00'N/39$^{0}$00'E<br>10$^{0}$42'N/37$^{0}$51'E | Area of rare fragile alpine vegetation<br>Area of rare fragile alpine vegetation<br>Area of rare fragile alpine vegetation |

| | | |
|---|---|---|
| *National Priority Forest protection Area*<br>20. Gera<br>21. Setema<br>22. Gimma<br>23. Komto<br>24. Chato<br>25. Guangua | $08^0$00’N/$36^0$18’E<br>$08^0$24’N/$36^0$06’E<br>$08^0$00’N/$36^0$42’E<br>$09^0$06’N/$36^0$36’E<br>$09^0$30’N/$37^0$00’E<br>$10^0$54’N/$36^0$30’E | Area of humid upland broadleaved Forest<br>Area of humid upland broadleaved Forest<br>Coffee shade forest<br>Natural forest enclosed by exotic forest<br>Possible watersheds/ wildlife protection area<br>Disturbed Natural Albizia Spp. forest area |
| *World Heritage Site*<br>26. Faisal Gimb | Gonder | World Heritage Site Gonder |
| *National Park*<br>27. Tis Abbay Waterfall | $11^0$30’N/$37^0$30’E | Scenic area; Tis Issat waterfall etc |
| *Cultural and Heritage Areas* | Numerous sites in all regions | |

In the Baro-Akobo sub basin, sensitive areas are those areas that have significant importance with regard to biodiversity conservation or for the preservation of items that have cultural and heritage significance. Gambela national park, which is seriously affected by refugees from the Sudan and encroachment by people living near the park and wetland areas around Gambela national park, which still affected by refugees are more sensitive areas.

Most of the Tekeze sub basin can be classified as an environmentally sensitive area comprising arid and semi arid land. This includes areas of environmental degradation, habitats of rare or endangered wildlife and cultural heritage sites and where development has reached high intensity and threatens to become unsustainable (e.g. in areas of high density urban or industrial development where water shortage and sanitation problems exist). Deforestation, soil degradation and erosion are key issues to be addressed in all Environmental Impact Assessments (EIAs) for development in the basin. This degradation has a knock-on effect on biodiversity conservation, public health and socio-economic conditions. Population pressures, (i.e tree felling for fuel and to clear land for crop cultivation) destroy wildlife habitats and are key factors in environmental degradation. The Tekeze sub basin is also rich in cultural heritage sites, which need to be safeguarded from negative environmental impacts.

Since most of the Tekeze sub basin area can be classified as environmentally sensitive, Environmental Impact Assessment (EIA) should be extensively used for screening most types of sectoral development proposals (e.g. livestock, apiculture, fisheries, crop cultivation, dams, hydropower and irrigation, industry, mining, energy development and tourism). However, the primary objective of some of the proposed projects can be viewed as mitigation (e.g. sectors of soil conservation, water supply and sanitation, wildlife conservation and some aspects of energy development) of existing problems. Most development projects may result in unsustainable levels of water extraction, crop cultivation can result in changes in soil fertility and development of pests. Irrigation projects, while raising fertility and providing extra food, can result in fluctuations in water table and increase in malaria infestation. Mis-managed tourism development, while generating income can result in degradation of cultural heritage site, and wildlife. Proposed industrial activities and mining development may have grave negative environmental impacts at local level if they are not monitored and regulated as part of environmental management programmes.



#### 5.1.6 Past and On-going Environmental Activities

Environmental issues are multi dimensional, and hence multi-sectoral. Related proclamations and regulations approved by the pertinent body are being implemented. According to these proclamations and regulations, sectoral agencies have to prepare environmental assessment plan prior to the implementation of development activities and programs. However, with low awareness and due attention given to the environmental issues, sectoral agencies are giving more focus and priority on the implementation of specific and short-term plans rather than long term environmental problems.

Mitigation of the enormous problem of land degradation in the Tekeze sub basin could only be achieved by joint action of all stakeholders including the local population. Protection of lands from erosion has started to get full attention of the responsible line agencies. Awareness of erosion increases rapidly in the rural communities. The extent of areas with traced cropland, comprising both old and recently built terraces is considerable and still increases rapidly. Terraced lands are concentrated mainly in the eastern, south eastern and northern part of the basin. Major concentrations of old terraces can be found in the eastern part of the basin.

Large tracts of recently terraced land exist in the west of Mekele town, and on the northeastern plateaux areas between Adwa and Indasilase. Remarkable is the virtual lacking of terraces around the town of Gonder, despite the high pressure on land resources there, and in the vast very steep escarpment zones north and west of the Gonder- to – Debark plateaux areas, where cultivation is randomly spreading beyond the edges of the plateaux.

## 5.2 Environmental Status and Key Forces of Environmental Degradation in the Lower Part of the Three Sub Basins (Sudan)

### 5.2.1 Environmental Status

#### 5.2.1.1 Dam Safety

The big variation in the Blue Nile and River Atbara flow between the high river during the flood season and the low river during the months from March to May has necessitated the construction of dams to store water for irrigation and for the generation of hydroelectric power. At present, there are three dams: Sennar (1 md.c.m.), Roseires (3.4 md.c.m.) and Khashm El Girba (1.3 md.c.m). However, the accumulated silt in the dam lakes has reduced the storage capacity by 25% in Roseires dam and by 40% in both Sennar and Khashm El Girba dams. Thus, heightening the Roseries dam to increase the storage capacity to 7.3 md.c.m. and constructing Siteit Dam across upper Atbara River to install additional storage capacity for irrigation projects are being seriously considered by the Sudan Government.

Sudan is now utilizing about 14.6 md.c.m. of its share of the Nile water for irrigation, of which 9.5 md.c.m. are from the Blue Nile, 1.7 md.c.m. from River Atbara, 1.8 md.c.m. from the White Nile and 1.6 md.c.m. from the River Nile. The heightening of Roseries Dam and the construction of new dams will enable the country to fully utilize its share of the Nile water, which stands currently at 20.5 md.c.m. at Sennar (18.5 md.c.m. at Aswan) according to the Nile Water Agreement of 1959. During the early eighties, Sudan and Egypt launched a joint project to excavate the Jongli canal and bypass part of the *Sudd* region, thereby sparing some 4 md.c.m. to be divided equally between the two countries. However, the project was hampered by the civil strife, which started in 1983 (NBSAP, 2003).

Dam building in Egypt and Sudan has caused severe environmental degradation in the past. These problems have never been independently evaluated. The Merowe/Hamadab Dam, which is currently under construction, is the largest hydropower project that is currently being developed in Africa. Once it is completed, a dam with a height of 67 meters on the fourth cataract of the Nile in North Sudan will create a reservoir with a length of 174 kilometres and a surface area of 476 square kilometres. The reservoir will displace about 50,000 people. (The project's Environmental Impact Assessment states that the reservoir will have a reach of 200 kilometres. This would affect a larger number of people, particularly on the island of Mugrat.)

The purpose of the Merowe Dam is to generate hydropower with an installed capacity of 1,250 megawatts. The project is expected to be completed between 2007 and 2009. It will roughly double Sudan's power generating capacity. According to the Environmental Impact Assessment, the project includes an irrigation component. According to environmental experts in Sudan, 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; and
- The spread of waterborne diseases. (IRN, 2005)

The Aswan High Dam, which created Lake Nasser, stretches back 270 kilometres. The Lake has also created a lot more land for people to farm on. This is because a lot of water is stored in the lake, and in turn this water can be used to irrigate land around the lake. Lake Nasser has also created a big fishing industry, which produces 25,000 tonnes of fish a year. The fishing industry is aiming to produce 100,000 tonnes by the year 2000. Unfortunately, this dam has caused a big change to the lives of farmers at the downstream. Usually 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. But now, since the dam was built the annual flood has been stopped. Causing all the farmers downstream to use fertilizers to grow their crops, making it more expensive to them.

#### 5.2.1.2 Biodiversity Related to Water

River Nile system is an important fresh water system in an otherwise very dry country. The most important biological diversity of this system is the Nile fish on the White Nile, Blue Nile and the swamp region. A total of 115 species of fish belonging to 27 families have been identified in the Nile. The threats facing the Blue Nile fisheries are the illegal fishing by mesh less than 40 mm, Bee-Bee, monofilament and operation of beach seines. There is also unfortunate use of poison in fishing operations. A third threat is the addition of plant leaves such as those of *Balanites aegyptica,* and *Lachnosiphononium niloticum*, and the roots of *Adenium obsum*. Heavy and continuous exploitation of Nile perch and the Nile carp which are class one commercial fishes in the fishing grounds near Damazin is causing over fishing. The rate of the present exploitation would lead to depletion of stocks. (NBSAP, 2000)

The flood region covers 10% of the country's area and is rich in fisheries and wildlife. The major threats to the zone include water hyacinth, pollution, and overall socio-economic development, particularly urbanization.

It is divided into swamp and wetland savannah, and grassland.

**Swamp and wetland savannah** has an average annual rainfall of 800 to 1000 mm. The vegetation includes the perennial *Cyperus papyrus* swamps of the "*sudd*" and the seasonally flooded "*toich*" area with *Hyphaene thebaica, Borassus aethiopum*, *Acacia seyal, A. siberiana* and *Balanites aegyptiaca* among the tree species.

**Grassland** has an average rainfall over 1000 mm known as the Toposa area, with *Hyparrhenia* sp*. Setaria* sp. *Chrysopogon plumulosus*, *Bothriochloa incipla* among the most important grasses with thickets of *Acacia mellifera* also present.

**5.2.1.3 The Biodiversity Country Study 2000** recorded a change, where an endemic species has been adversely affected by an alien species, is the case of the Nile cabbage, *Pistia stratoites*. Up to 1957, this species was the largest free-floating macrophytes in the Nile system in the Sudan. In 1957, the exotic water hyacinth, *Eichhornia crassipes*, reached the Nile system in southern Sudan. It has since spread and largely replaced the once abundant Nile cabbage. The growth forms of the two species account adequately for the replacement. *P. Stratiotes* persists in temporary pools, where it seeds freely and thus survives the dry season. It is also found within swamps, in sites remote from the river. The case of the Nile cabbage could be repeated and other native species could be threatened if alien species are introduced accidentally or intentionally.

**The Environmental Protection Act 2001** requires in article 18 that an environmental impact assessment study should accompany any project that is likely to have a negative impact on the environment or natural resources. It also outlines penalties for air pollution, pollution of water sources such as river, sea, lakes, ponds, canals, storage facilities, and natural or man-made pollution of food, pollution of the soil, and pollution by radiation or noise pollution.

**Special water- Related Environmental Issues**

To irrigate the Gezira scheme for cotton production, an extensive network of canals has been created, extending from the Blue Nile to the Central Clay Plain. The lower category of the network is called the minor canals, which are effectively stagnant pools of water. Here an artificial habitat for submerged aquatic species has been created. The presence of these plants requires regular dredging of canal so that irrigation water conveyance is not impeded. The spread of these water plants has also assisted the spread of vectors of the disease bilharzia, which infects a very high percentage of the population (NBSAP, 2000).

A pollution threat comes from herbicides, insecticides, which are applied in the riverside agricultural scheme and are washed into the river by irrigation canals. Another source of water pollution comes form the effluents of sugar factories, which are discharged, untreated into the river (NBSAP, 2000).

### 5.2.2 Key Forces of Environmental Degradation

**Environmental Sustainability Index**

In the 2005 Environmental Sustainability Index (ESI), Sudan was ranked among the 10 bottom countries, 140 out of 146. This reflects a low environmental performance taking the five standard measurement component (Environmental System, Reducing Environmental Stresses, Reducing Human Vulnerability, Social and Institutional Capacity, Global Stewardship levels that cause no serious harm.), shown in Fig (1) below. This ranking qualified Sudan to be part of the Cluster 2 groups of countries – which include countries that are least-developed, most of whom experience relatively low environmental stress, but have very weak institutional capacity and are particularly vulnerable to natural disasters, under nourishment and lack of sanitation and safe water supply. ESI (2005)

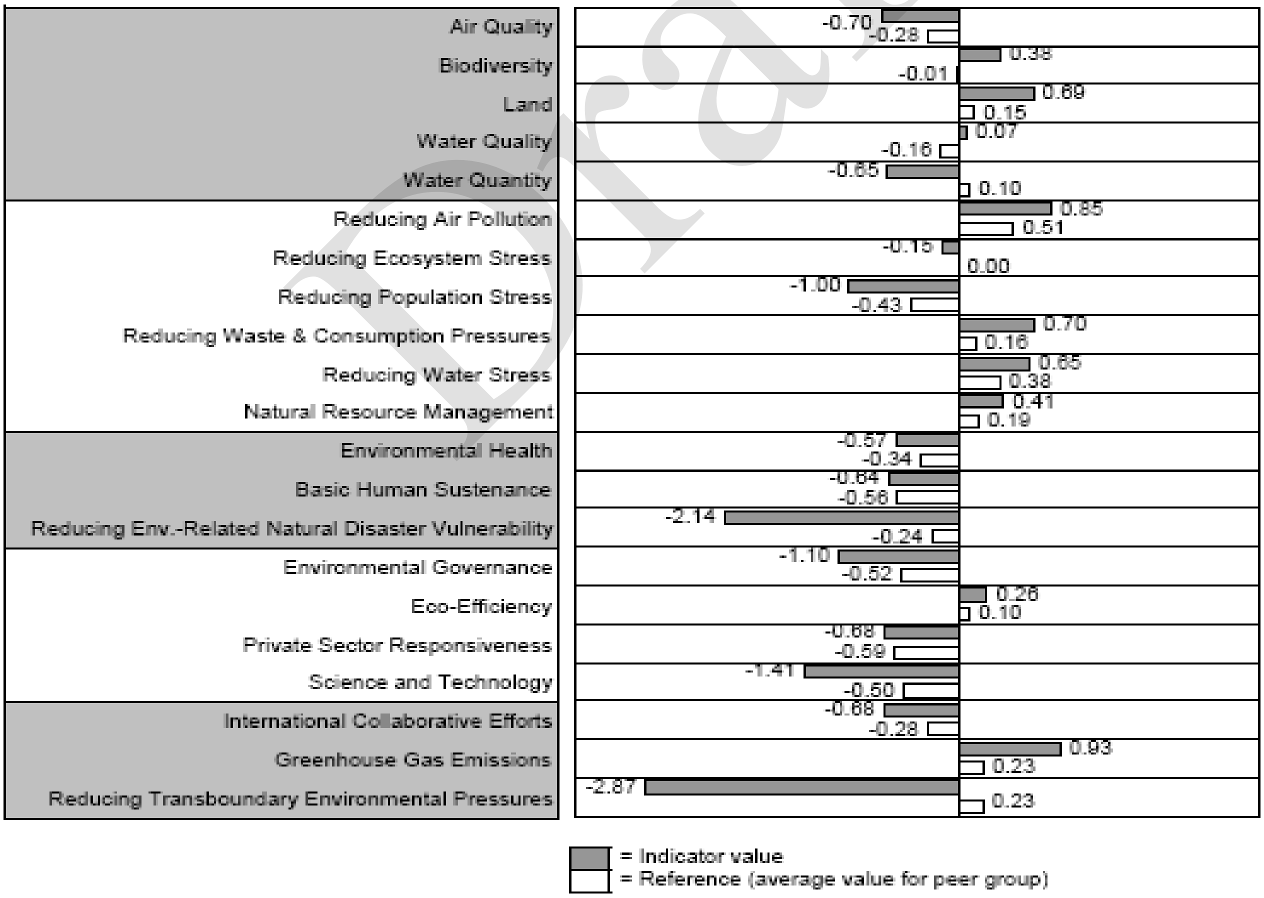



Fig 6. Profile of Sudan (2005)

#### 5.2.2.1 Climate Variability and Change

Climatic variability is generally reflected in the form of severe drought and occasional floods, which Sudan is suffering from. For over three decades from the 1970s, recurrent droughts, with occasional severe ones, had become normal phenomenon in Sudan as well as in most of the Sudano-Sahelian region. The Sahel region seems to have undergone a general decline of rainfall since the late 1960s. Between 1961 and 1998, episodes of drought have inflicted Sudan with varying severity. The most severe droughts of the early mid 1970s and ten years later of the early mid 1980s have brought about a number of negative impacts leading to the breaking down of the social fabric and the traditional tribal structures, undermining the overall coping capacities and ultimately the mass migration of rural population to urban centres.

Climate change is expected to increase the frequency and severity of climate variability (IPCC, 2001), and African countries are expected to be the hardest hit by its negative impacts. Sudan is particularly concerned with impacts of climate change, as the majority of its land is quite vulnerable to changes in temperature and precipitation. Besides, Sudan possesses fragile ecosystems and poor infrastructure and economy. The country's inherent vulnerability may best be captured by the fact that food security in Sudan is mainly determined by rainfall where more than 70% of the Sudanese people are directly dependant on climate sensitive resources for their living.
As with drought, two types of floods affect the country: localized floods caused by exceptionally heavy rainfall and runoff (flash flood); and widespread floods caused by overflow of the River Nile and its tributaries. Places impacted are mostly lowlands and areas around the Nile and other stream wadis.

#### 5.2.2.2 Land Degradation

Land degradation has now become a serious threat to the survival of a majority of Sudanese population. Over the past few decades, Sudan has seen a dramatic decline in its forest reserves. Lack of an integrated land use and plans, institutional problems (conflicting mandates, lack of capacity etc.), ad hoc government policies regarding the use of natural resources, horizontal expansion of rain-fed mechanized and traditional farming, heavy reliance on forest biomass energy, overgrazing, bush fire, etc. have been the key factors. Despite their existence, several forest legislations lack legal enforcement. The National Biodiversity Strategy and Action Plan (SNBSAP, 2002) and Sudan's National Action Plan to Combat Desertification (SNAP, 2003) have also identified improper land use as a leading threat to the country's biodiversity and have recommended the need to develop land tenure policy and legislation.

#### 5.2.2.3 Unsustainable Agricultural Practices

Unsustainable agriculture has manifested itself in the form of reliance on seasonal bush and grassland fires for purposes of preparing land for cultivation, pastoralism, overgrazing in some regions of the country and limited extension services. The biggest challenge Sudan faces in the agricultural sector is the low productivity. The extreme rainfall variability has made traditional farmers highly vulnerable to drought.

In addition, there are:

- Desertification, land degradation and excessive use of pesticides and fertilizers.
- Poor infrastructure (irrigation, transport, market etc.);
- Instability of marketing policies, land ownership and use;
- Lack of modern agricultural inputs, as the traditional sector is reported to have no access to fertilizers, as well as in finance and marketing;
- Malaria, salinity, and notorious weeds are among the biggest problems in rural agricultural areas.

Reports of the Forest National Corporation (FNC) show that an estimated 455,000 ha of forestland is being cleared annually for agriculture and other purposes. Moreover, on the sandy soils of the Sudan, the shortening of the fallow period brought a negative impact by retarding the natural regeneration of the gum Arabic tree. Another aspect of the horizontal expansion of agriculture affected the natural rangeland in that inter-communal tension and conflict are resulted between herders and cultivators.

### 5.2.2.4 Wetland Loss and Degradation

Wetlands are less understood but are most important environmental resource of any country. They have huge economic, social, climatic and hydrological benefits. Given the global significance of Sudan's wetlands, halting wetland degradation would require immediate regional and global attention. However, there is lack of awareness of the hydrological, economic, climatic and social benefits of wetlands. Wetlands can also be easily lost or degraded through direct drainage for cultivation, grazing, and increase in water supply downstream (e.g., the Jonglei Canal project) or indirectly through sedimentation and pollution. The Jonglei Canal Project and the War in Southern Sudan pose serious threat to wetlands of Sudan.

### 5.2.2.5 Loss of Soil Nutrients

Mono-cropping farming system, years of extensive cultivation practices by the mechanized and traditional rain-fed sectors, with limited or no access to fertilizers and improved farming techniques compounded by wind and water erosion have left most soils of Sudan nutrient depleted. Siltation, sedimentation, persistent organic pollutants (POPs), and aquatic weeds (water hyacinth) -though quantitative evidence is not strong- have emerged as potential threats to consider. Water hyacinth, for example, has infested 3200 kilometres of the White Nile.[1]

### 5.2.2.6 Deforestation

According to FOSA (2000), the forest and woodland area in Sudan currently amounts to 85.9 million hectares, which is continuously being encroached upon by agriculture and urbanization or otherwise degraded by uncontrolled felling. This area represents 34.5 percent of the total land area of the country. The forest reservation process started in 1923 was only able to settle and finally gazette (1.26 million hectares) by 1993 (equivalent to 0.5 percent of the total area of the country). At 1999, the forest reserves area was about 8.86 million hectares (constituted as forest reserves and under reservation), which made 3.6% of the total area of the country of which about 7,738 thousand hectares are in the Northern States, classified as follows:

- Revirine forests amount to 523 thousands hectares (under management plan);
- Montane forests amount to 180 thousands hectares (only at Jebel Marra forest the plantation is under management plan);
- Dahara forests (Rainfed) amount to 7 million hectares (most of the area is natural forests, the rest had been degraded so reforestation took place).

Another 250 thousand hectares are reserved to the community as natural forests in the period 1994/99. Afforestation and reforestation activities are restricted to areas constituted as reserves and subsequently put under management, almost exclusively owned by FNC

The on-going process of environmental degradation is a critical issue that affects the livelihoods of a large sector of the population. Removal of tree cover for crop production, felling trees for fuel wood and building poles, overgrazing and drought conditions are resulted in desertification and consequently, shortage in food crops, and loss of soil fertility. These environmental changes severely affected different sectors of the population, particularly in rural areas.

### 5.2.2.7 Desertification

About 51% (1,259,440 square kilometres)[2] of Sudan's land area, between latitude 10 to 18 degrees north, is affected by desertification ranging from light to severe (See Table 4 below). This area is characterized by extreme arid conditions continuously fed by recurrent drought, land degradation, deforestation and soil nutrient loss. Studies conducted by NDDU showed the shift of the rainfall isohyets during the period 1930-1990 from north to south indicating the expansion of arid condition from north to south. Moreover, Sudan's National Action Plan to Combat Desertification (SNAP) indicated that thirteen of the 26 Sudan's states could be classified as desert or semi-desert. It should be noted that there are no recent plans/policies for sustainable agricultural land use in the Sudan, despite the 1970's agricultural policy (developed with UNDP-FAO support). Government policies remain influenced by traditional regulations and practices. The Agriculture Sector Strategy (2002-2007) now under preparation should ensure that policies to combat desertification are given high priority and form an integral part of national policies.

[1] SNBSAP, p.35

[2] Sudan National Action Plan to Combat Desertification (SNAP), p. 15

Table 26: Extent of desertification in the Sudan

| Rainfall (mm) | Total Area (1,000 Km$^{2)}$ | Latitude N | Area Affected 1994 (1,000 Km $^{2)}$ | Desertification Class |
|---|---|---|---|---|
| 0-100 | 307 | 14-18 | 74,908 | Desert |
| 00-300 | 414 | 13-14 | 136,206 | Very Severe |
| 300-800 | 513 | 12-13 | 208,791 | Moderate |
| 600-800 | 25 | 11-12 | 500 | Very Slight |
| >800 | 0.8 | 10-11 | 0.8 | Very Slight |
| Total | 1,259.8 (a) | | 420,405.8 (b) | (b/a)= 32.9% |

*Source: Ministry of Agriculture, NDDU, 1999*

### 5.2.2.8 War and Civil Strife

Sudan has suffered from more than 40 years of war and civil strife in the southern part of the country. This had tremendous impacts on the natural resources and biodiversity arising from indiscriminate clearing of forests to meet military requirements, hunting of endangered animal species and the selective cutting of rare forest species (e.*g Tectona grandis* (Teak)) to finance the war.

### 5.2.2.9 Population Pressure and Urbanization

With an estimated total population of 31 million (2003), current population density in Sudan is calculated as 12 persons/km$^2$. This figure gives a false indicator of population distribution when cultivable land is considered and where the population density increases to 31.4 persons/km$^2$. Moreover, it increases as high as 370 persons/km$^2$ when considering actual land presently cultivated along the Nile. According to ElTayeb, G.2002, urban populations had increased by over 50% between 1993 and 1996, in every single State and by the end of year 2002, Greater Khartoum dwelling constituted 20% of the total population. This is attributed to the massive population displacement and accelerated rural-urban migration. While the annual rate of population growth has remained the same, total population and urbanization have increased, demanding more material and immaterial provisions.

### 5.2.2.10 Poverty

The Poverty Reduction Strategic Plan (PRSP) of 2004 indicated that; there is an increasing trend in poverty levels as well as an increase in the relative rural/urban poverty rates due to negligence of the rural sector. Many factors are said to have contributed to this situation, including: liberalization of the economy without the necessary social safety nets, lack of social services, means of production and institutional and legislative frameworks, repeated drought intervals, desertification, the civil war in the south and other parts of the country. The rural population has been the hardest hit as many of the poor people are in the rural areas, and live in marginal lands and drought prone areas. In response to the international community call for poverty reduction, the Sudanese government initiated the Poverty Reduction Strategy Process (PRSP) in 1999. A higher council chaired by the President of the Republic was established by presidential decree in the year 2000, to supervise the preparation and implementation of a comprehensive program for Poverty Reduction. The main objectives of the Poverty Reduction Strategy Process are to maintain economic stability, ensuring political stability (through peace process), achieve social stability, increasing the standards of living, assistance in achieving debt relief and the flow of external funding.

## 5.3 Water Quality and Environmental Threats in the Main Nile Sub Basin (Egypt)

This section describes the current monitoring programs, types and sources of water quality problems of the River Nile System. It evaluates the water quality monitoring programs and data quality.

### 5.3.1 Water Resources

The main water resource in Egypt is the River Nile. It constitutes 96% of the renewable water resources in accordance with the Agreement on Full Utilization of the Waters of the Nile concluded between Egypt and Sudan in 1959. Under this agreement, Egypt's annual quota of the Nile water is 55.5 billion cubic meters, while Sudan's is 18.5 billion cubic meters. Moreover, the volume of seasonal rains on coasts and Sinai is 1.3 billion cubic meters annually.

Other water resources are the renewable and non-renewable groundwater in deserts. Current water uses are a mix of direct utilization of main resources, and indirect one; namely reuse of agricultural drainage and treated wastewater.

Figure 2 shows the direct use of renewable water resources is represented in 55.5 billion cubic meters of Nile water, 1.3 billion cubic meters of rains, and 0.9 billion cubic meters of non-renewable groundwater in Eastern and Western Deserts and Sinai. Indirect use is represented in 6.1 billion cubic meters of renewable groundwater in Nile Valley and Delta, 7.5 billion cubic meters of agricultural drainage reuse, 7.8 billion cubic meters of industrial effluents reuse, and 1.4 billion cubic meters of treated wastewater. The use of water resources in different sectors includes agriculture (58.65 billion cubic meters), industry (7.5 billion cubic meters) and drinking or household (4.75 billion cubic meters) in addition to Nile navigation and power generation.

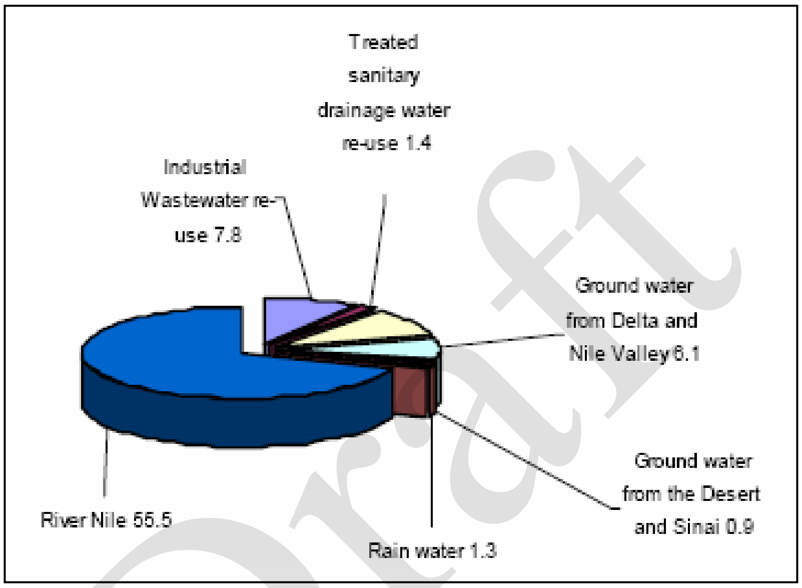



Fig. 7 Use of renewable water resources in Egypt (*source: State of Environment, 2005)*

Increasing water needs are due to population growth, standards of living improvement and the state policy aiming at reclamation of new lands, encouragement of industry and maximization of clean water accessibility. Closing the gap between the available water resources and the increasing water demand by the various economic sectors is a major challenge facing Egypt today.

However, Egypt endeavours to make the optimum use of potable water and non-conventional water resources such as desalination of seawater, reuse of agricultural drainage and treated wastewater.

The Government aims to improve water resources management and increase the efficiency of their use through further utilizing modern irrigation methods to decrease the waste. The work involved raising grassroots awareness with respect to the importance of rationalizing the consumption of water in irrigation, industry and household, and protecting water resources against pollution, as well as involving people in water policies formulations.

The agricultural sector is the largest water consumer in Egypt. Its quota is almost 85% of the total water demand. During 1980- 2000, cultivated area has increased from 5.8 million acres to 7.95 million acres. Yield productivity jumped by nearly 180%. Rice and sugarcane are the largest water consuming crops in Egypt. Agricultural expansion has contributed effectively to reducing poverty and hunger, and providing food security.

With population growth, however, any attempt of agricultural expansion would require more provision of irrigation water. This necessitates improving irrigation water use, agricultural drainage water reuse, and groundwater utilization. National programs have been adopted to improve irrigation systems, reuse of agricultural drainage and treated wastewater, and make the optimum use of groundwater.

Water quality differs according to locations, flows, water uses, population density; type of pesticide and fertilizers used in cultivation, sanitary drainage and industrial effluents systems, in addition to social and economic conditions. Therefore, preserving the good quality of water is the major environmental challenge in Egypt.

### 5.3.2 Monitoring Programs

A number of government ministries have responsibility for water quality issues in Egypt. No organization has clear responsibility for managing River Nile water quality. Although currently proposed legislation would give the Egyptian Environmental Affairs Agency (EEAA) an overall responsibility for coordinating environmental program, its exact rule is not clear.

The following section presents a brief summary of the various agencies that were identified as being potential sources of relevant and reliable data for water quality controls.

#### *5.3.2.1 Ministry of Water Resources and Irrigation (MWRI):*

MWRI has, through the National Monitoring Program for assessing and monitoring Surface and Underground Water, 320 surface water sites, along canals, main canals, the Nile, Lake Nasser, and drains located in strategic locations, in addition to 250 sites along groundwater aquifers network. MWRI monitors the general indicators of water quality including natural, chemical and biological parameters (such as salts, cations, anions, bacteriological and organic pollutants, dissolved oxygen, BOD, COD, heavy elements, and…other).

#### *5.3.2.2 Ministry of Health and Population (MoHP)*

The MoHP undertakes four programs related to water quality monitoring. One of these is related to the adequacy of potable water treatment with the objective of ensuring that all such treatment plants in Egypt meet drinking water standards.

Ministry of Health (MoH) regularly monitors the quality of the Nile water in 10 governorates; *Aswan, Sohag, Asiout, Menia, Beni Suef, Gharbeya, Daqahleya, Damietta, Alexandria, and Port Said.* The MOHP conducts an industrial discharge monitoring program jointly with MWRI. Also, the MOHP monitors the discharge from major wastewater treatment plants on a quarterly basis. The program includes 86 of the 104 operating plants throughout Egypt

#### *5.3.2.3 Egyptian Environmental Affairs Agency (EEAA)*

EEAA runs annual monitoring program for Nile water quality. The EEAA has two units that monitor water quality of the Nile River.

***5.3.2.4 The Environmental Quality Sectio****n* is responsible to monitor ambient water quality of the Nile River. Their program commenced in 1999 and consists of sampling on an annual basis. The first year's program included 18 sampling points and the network has expanded to 31 points in the 2001 program.

*The Environmental Inspection Unit (EIU*) is charged with monitoring industries that discharge wastewater to waterways. They monitor approximately 550 industries that discharge wastewater into the Nile River and agricultural drains. They verify compliance with Law 48 and the terms of their discharge license. Violators are given 90 days to rectify the problem and letters are delivered to MWRI and the Governor of the area where the violation takes place. The EIU returns to the violator after 90 days to check to see if the violation has been rectified. For non-violators, they are rechecked on a random basis. A comprehensive database of the 550 industries is maintained by the EIU.

#### *5.3.2.5 Ministry of Housing, Utilities and New Communities (MHUNC)*

The National Organization of Potable Water and Sanitary Drainage (NOPWASD) within MHUNC has the responsibility for planning, design and construction of municipal wastewater treatment plants and sewage collection systems.

### 5.4 Sources of Pollution in the Main Nile Sub Basin (Egypt)

The protection of water resources is one of the most critical environmental issues in Egypt. Egypt is facing an increasing demand for water due to the rapidly growing population, as well as the growth in urbanization, agriculture and industry. In the meantime, Egypt faces a rapidly increasing deterioration of its surface and groundwater due to increasing discharges of heavily polluted domestic and industrial effluents into its waterways. Excessive use of pesticides and fertilizers in agriculture also causes water pollution problems.

An assessment of water quality in Egypt indicated that the major water quality problems are pathogenic bacteria/parasites, heavy metals and pesticides. Major sources of these pollutants are the uncontrolled discharge of human, industrial and agricultural wastes.

The sources of pollution on the river Nile system, starting from Aswan till Delta Barrage, Nile branches, main canals and drains will be carefully identified in this section. Figure 3 shows the industrial and domestic wastewater outfall points schematically while Figures 4 and Figure 5 depict the agricultural drain outfalls and monitoring network along the Nile, Canals and Drains.

*"It is worth mentioning that this section includes the analysis and assessment of water quality **"AVAILABLE"** data that have been recorded during the February 2001-Monitoring Campaign by MWRI". However, MoHP 2003- Water quality monitoring Campaign is also included in a separate annex.*

#### 5.4.1 Industrial Pollution

Egyptian industry uses 638 $Mm^3$/yr. of water, of which 549 $Mm^3$/yr. are discharged to the drainage system. Industrial activities in the Greater Cairo and Alexandria regions use 40% of the total. The River Nile supplies 65% of the industrial water needs and receives more than 57% of its effluents. More detailed information about water consumption, wastewater discharge and point sources of pollution and loads from different industrial sectors are provided in Tables 5 to 8.

##### 5.4.1.1 Upper Egypt

Sources of industrial pollution along the Nile in Upper Egypt area are mainly agro-industrial and small private industry. Sugar cane industries significantly influence Nile water quality at Upper Egypt-South zone. Hydrogenated oil and onion drying factories influence Nile water quality at Upper Egypt-North zone.

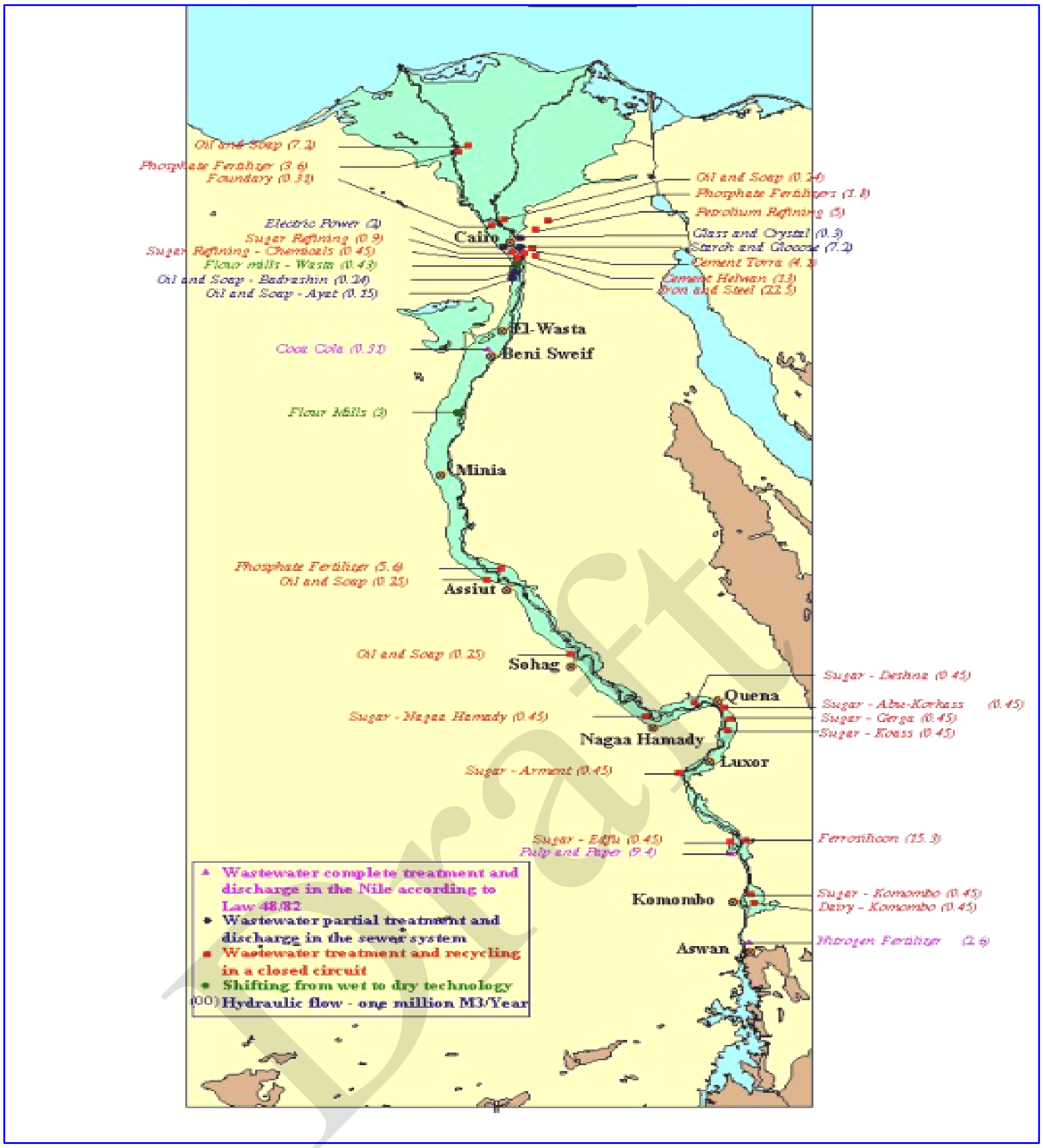
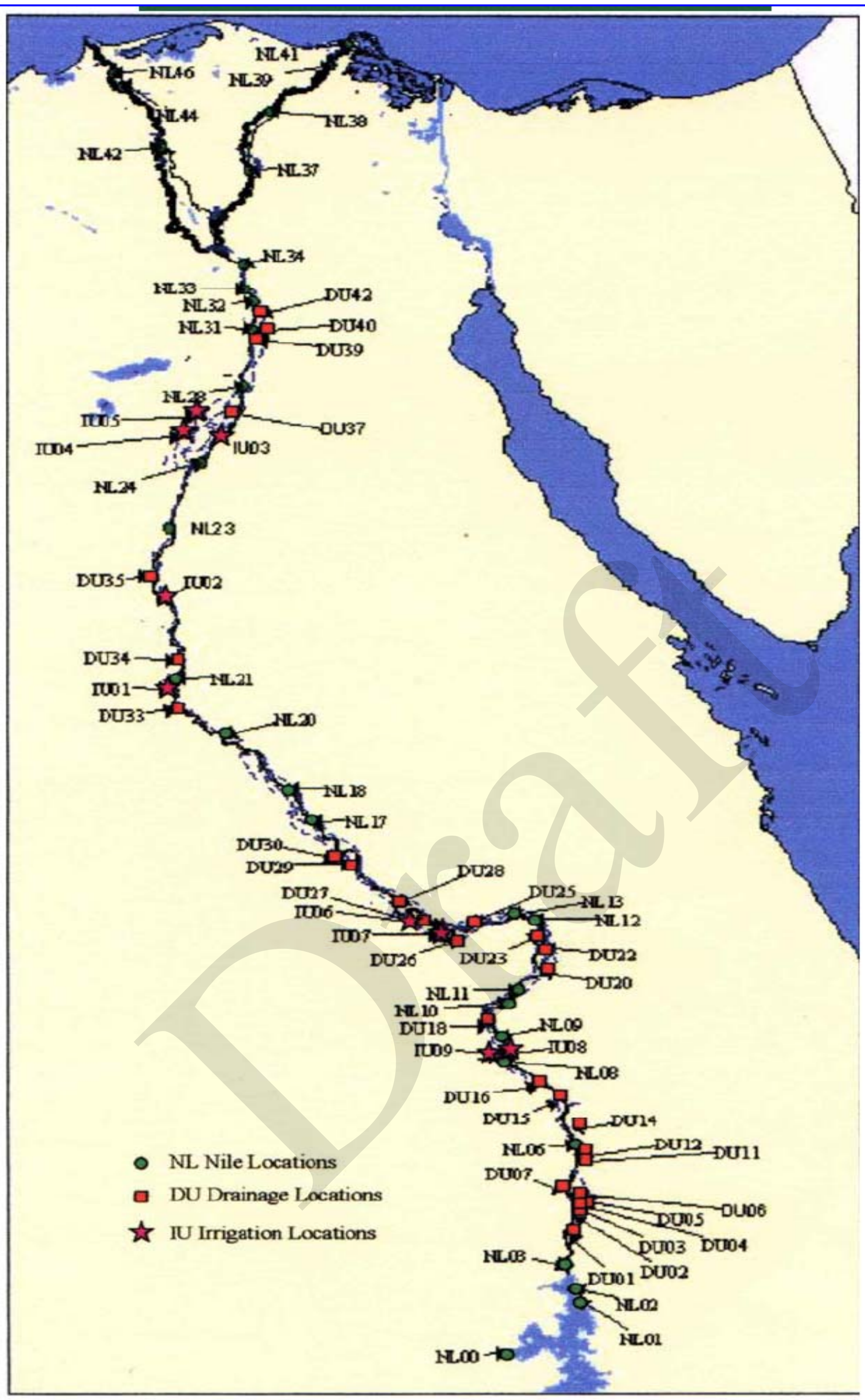



Fig. 8: Point Sources (Pollution- Map)

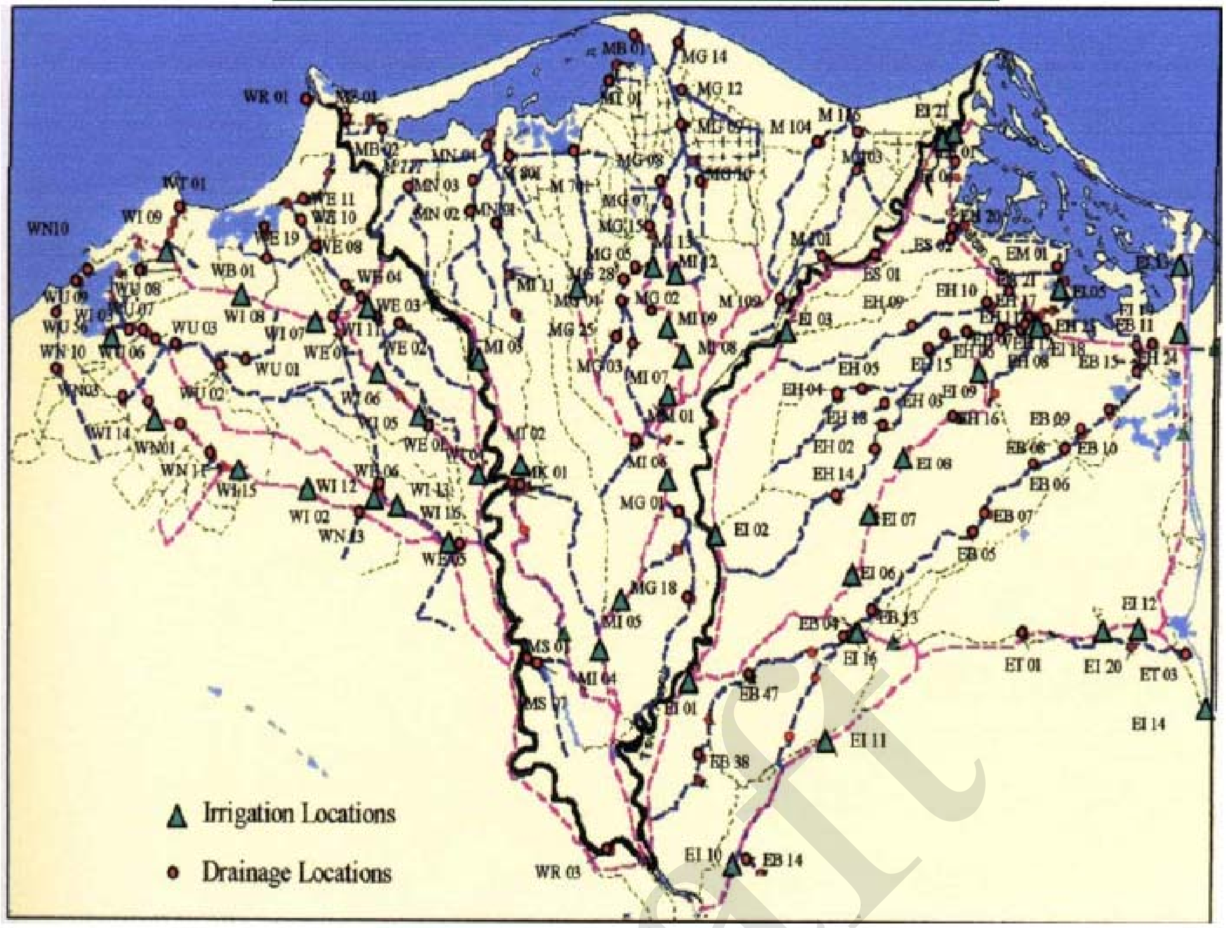
### 5.4.1.2 Greater Cairo

The area has a population of approximately 18 million and encompasses many industrial and commercial activities. Heavy industry is located around, south of Cairo, and north of Cairo. Many small industries and some heavy industry are randomly located throughout the city.




Source: MWRI The National Water Provision and Quality Improvement Project (1992-2005)

Fig. 9: Water Quality Monitoring Network along the Nile




Source: MWRI The National Water Provision and Quality Improvement Project (1992-2005)

Fig. 10: Canals and Drains Water Quality Monitoring Network



Although wastewater discharges of the small industries are generally low, concentrations of certain industries in specific areas, such as the tanning industry may cause local contamination problems. An overview of pollution sources is given in Figure 3. They include 23 chemical industries, 27 textile and spinning industries, 7 steel and galvanizing industries, 32 food processing industries (including a brewery), 29 engineering industries, 9 mining and refraction industries, and petrol and car service stations, bakeries (>350), marble and tile factories (>120) and tanneries in South Cairo.

### 5.4.1.3 Rosetta and Damietta Branch

The Rosetta receives the water of a number of agricultural drains, which are heavily polluted by industrial and domestic sewage. The drains receive large parts of the wastewater of Cairo. The wastes in the drains contain high levels of suspended and dissolved solids, oil, grease, nutrients, pesticides and organic matter. It is suspected that toxic substances are present as well. The Damietta Branch also receives polluted water of a number of agricultural drains; The Fertilizer Company is considering the major point source of industrial pollution at Damietta branch.

At present industrial use of water is estimated at 5.9 BCM/year out of which 550 MCM/year is discharged untreated into the River Nile. About 125 major industrial plants are located in the Nile valley, which represent about 18% of the existing industries and discharging 15% of the heavy metal loads. About 250 industrial plants are located in Greater Cairo, which represents 35% and contributing about 40% of the total metal discharges. The Delta excluding Alexandria has some 150 industries, which contribute about 25% of the heavy metals discharging to drains. Alexandria is a major heavy industrial centre with some 175 industries, about 25% of the total in Egypt.

Table 27: Industrial wastewater discharge to the river Nile system

| District | Ultimate sink (M $m^3$/yr.)* | | | | Total |
|---|---|---|---|---|---|
| | Nile | Canals | Drains | Lakes | |
| Upper Egypt | 192 | 5 | 2 | 5 | 204 |
| Greater Cairo | 80 | 21 | 20 | 7 | 128 |
| Delta | 27 | 85 | 13 | 1 | 126 |
| Alexandria | 13 | 7 | 33 | 35 | 88 |
| Others | 0 | 0 | 3 | 1 | 4 |
| Total | 312 | 118 | 71 | 49 | 550 |

*Source: Wahaab, R.A.and Badawy, M.I. (2004)*

Table 26 Water use and wastewater discharged from different industrial sectors

| Industrial Sectors | ($Mm^3$/yr.) | | | |
|---|---|---|---|---|
| | No. of Plants | Water Use | Water Discharge | Consumption |
| Chemical | 53 | 127 | 98 | 29 |
| Food | 119 | 296 | 277 | 19 |
| Textile | 75 | 114 | 88 | 26 |
| Engineering | 39 | 13 | 12 | 1 |
| Mining | 11 | 69 | 60 | 9 |
| Metal | 33 | 19 | 14 | 5 |
| Total | 330 | 638 | 549 | 89 |

*Source: Wahaab, R.A.and Badawy, M.I. (2004)*

Table 29: Pollution loads discharged to different districts

| District | Flow ($Mm^3$/d) | (ton/day) | | | | | |
|---|---|---|---|---|---|---|---|
| | | BOD | COD | Oil | TSS | TDS | HM |
| Upper Egypt | 204 | 37 | 72 | 5 | 68 | 532 | 0.20 |
| Greater Cairo | 128 | 71 | 120 | 93 | 97 | 135 | 0.75 |
| Delta | 125 | 34 | 42 | 24 | 86 | 224 | 0.50 |
| Alexandria | 88 | 91 | 186 | 45 | 40 | 246 | 0.17 |
| Other Gov. | 5 | 2 | 3 | 1 | 5 | 15 | 0.03 |
| Total | 550 | 235 | 423 | 168 | 296 | 1152 | 1.65 |

*Source: Wahaab, R.A.and Badawy, M.I. (2004)*

Table 30: Pollution loads from different industrial sectors

| Industrial Sectors | Flow ($Mm^3$/d) | Ton/day | | | | | |
|---|---|---|---|---|---|---|---|
| | | BOD | COD | Oil | TSS | TDS | HM |
| Chemical | 98 | 26 | 178 | 23 | 33 | 241 | 0.94 |
| Food | 277 | 142 | 182 | 110 | 168 | 666 | 0.17 |
| Textile | 88 | 39 | 47 | 24 | 64 | 191 | 0.30 |
| Engineering | 12 | 5 | 7 | 2 | 3 | 13 | 0.03 |
| Mining | 60 | 14 | 17 | 8 | 24 | 29 | 0.20 |
| Metal | 14 | 3 | - | 1 | 4 | 11 | 0.01 |
| Total | 549 | 225 | 431 | 168 | 296 | 1151 | 1.65 |

*Source: Wahaab, R.A.and Badawy, M.I. (2004)*

#### 5.4.1.4 Alexandria Area

Alexandria is a major industrial centre with some 175 industries, about 25 percent of the total in Egypt. These industries include paper, metal, chemical, textile, plastic, pharmaceutical, oil, soap, and food processing. The plants are reported to contribute some 20 percent of the total wastewater of Alexandria. The industries discharge their effluents mainly to Lake Mariut and partially to the sewerage network. According to a survey made by Drainage Research Institute, different types of industrial wastes are disposed to Lake Maryut. At least 17 factories discharging directly to the lake through pipelines, 4 factories collect their wastewater in trenches. Moreover, 19 factories lying in the vicinity of the treatment plants, 22 factories discharging to nearby drains and then to the lake.

It is worth mentioning that the total amount of BOD discharged to the river Nile by industrial plants equals 270 ton/day. This amount corresponds to the untreated discharge of wastewater from more than six million people. It can be concluded that these substances are discharged mainly from the industrial activities in the Greater Cairo region and in Delta (0.75 and 0.50 ton/day). The average concentration of heavy metals (HM) in the effluent is less than 5 g/1, which is slightly, more than a normal background.

The results represented in Table 6 shows that the food processing industry is responsible for more than 50% of the BOD load. However, the chemical industry is responsible for more than 60% of the heavy metal discharges. The high BOD load from the food processing industry is attributable to 10 sugar factories between Aswan and Cairo, for which the total BOD load was estimated at 490 ton/day in 1980. More recently the BOD load from some sugar factories has been reduced significantly due to recovery of molasses at the source. Since the economic viability of this industry is not clear, a restructuring program for the industry would need to consider both environmental and economic viability issues for the industry.

### 5.4.2 Domestic Pollution

Available information revealed that the total wastewater flows generated by all governorates, assuming full coverage by wastewater facilities, is estimated to be 3.5 BCM/year. Approximately, 1.6 BCM/year receives treatment. By the year 2017, an additional capacity of treatment plants equivalent to 1.7 BCM is targeted (National Water Resources Plan, 2002). Although the capacity increase is significant, it will not be sufficient to cope with the future increase in wastewater production from municipal sources, and therefore, the untreated loads that will reach water bodies are not expected to decline in the coming years, as demonstrated in Table 8.

In many cases, domestic wastewater is collected from the centre of the towns and from the villages and, dumping it into a nearby irrigation canal is quite common· Therefore, domestic waste disposal significantly contributes towards water quality degradation. It is worse mentioning that no well-controlled sludge management program exists in Egypt. This may, especially in urban areas such as Greater Cairo, lead to inadequate sludge disposal, cause general environmental problem and, in the worst case, eventually influence water quality in a negative way.

Table 31: Projections of wastewater treatment coverage

| Year | Population | People Served | People Not Served |
|---|---|---|---|
| 1997 | 60 Million | 18 Million | 42 Million |
| 2017 | 83 Million | 39 Million | 44 Million |

The constituents of concern in domestic and municipal wastewater are: pathogens, parasites, nutrients, oxygen demanding compounds and suspended solids. In Greater Cairo and other cities, the sewerage systems also serve industrial and commercial activities. Therefore, instances of high levels of toxic substances in wastewater have been reported. As these toxic substances (heavy metals and organic micro-pollutants) are mainly attached to suspended material, most of it accumulates in the sludge. Improper sludge disposal and/or reuse may lead to contamination of surface and ground water.

In general, the bulk of treated and untreated domestic wastewater is discharged into agricultural drains. Total coliform bacteria reach 106 MPN/100 ml as recorded in some drains of Eastern Delta. It is important to mention that all drains of Upper Egypt flow back into the Nile. Many irrigation canals and agricultural drains may be contaminated with pollutants from domestic and industrial sources. Moreover, many of irrigation and agricultural drain are used for irrigation.

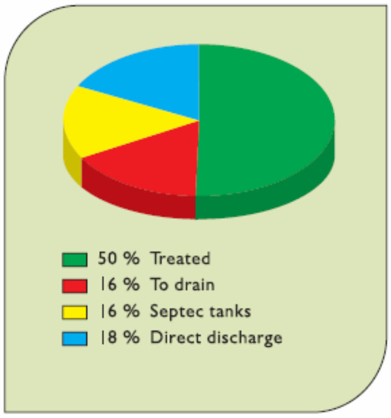



Fig 11: Domestic Wastewater in Egypt *(Source: MWRI, 2005)*

### 5.4.3 Wastewater Treatment Systems

The treatment systems in Egypt can be divided into two basic types: aerobic and unaerobic treatment. The four most common aerobic treatment technologies are activated sludge, aerated lagoons, oxidation ponds, trickling filters and rotating biological contactors (RBC). Activated sludge and oxidation dishes represent 58% of the technologies and 72% of the total wastewater treatment capacity (El-Gohary, 2002). In Greater Cairo, the capacity of the El Gabal El Asfar secondary treatment plant (WWTP) was $3x10^6$ $m^3$/day and services 12 million people. A secondary WWTP with $0.33x10^6$ $m^3$/day treatment capacity exists at El-Zenein and $0.4x10^6$ $m^3$/day treatment plants exist at Berka ($0.6x10^6$ $m^3$/day to primary standard) and Shoubra El-Kheima (about $0.6x10^6$ $m^3$/day).

Fifty-nine waste water treatment plants with total capacity of approx. 3,700,000 $m^3$ /day are operational; 34 are under construction, with a total capacity of almost 5,000,000 $m^3$ /day (Table 4). Most of the installed treatment plants provide some form of secondary treatment, although not all of them are functioning well.

Table 32: Overview of types of operating Wastewater Treatment Plants in Egypt

| Type of Treatment | Number of WWTP | Installed Capacity | Average Capacity | Minimum Capacity | Maximum Capacity |
|---|---|---|---|---|---|
| Primary Treatment Only | 1 | 720.000 | 720.000 | 720.000 | 720.000 |
| Fixed Film reactors Trickling Filter | 19 | 625.000 | 32.895 | 12.000 | 75.000 |
| Activated Sludge | | | | | |
| Conventional Act. Sludge | 9 | 1.911.000 | 212.333 | 26.000 | 600.000 |
| Oxidation Ditch | 14 | 88.740 | 6.339 | 550 | 50.000 |
| Small Ready Made Systems | 4 | 4.040 | 1.010 | 600 | 2.200 |
| Oxidation Ponds | 9 | 242.600 | 26.956 | 300 | 75.000 |

| | | | | | |
|---|---|---|---|---|---|
| Aerated Oxidation Ponds | 3 | 108.00 | 36.000 | 22.000 | 60.000 |
| Total | 59 | 3.699.380 | 62.701 | 781.450 | 1.582.200 |

Table 33: Wastewater Treatment Facilities & Ultimate Sinks along the river Nile System.

| **Region** | **Type of Treatment** | **Discharge Towards** | ***Capacity [m³/day]** |
|---|---|---|---|
| **Upper Egypt** | | | |
| 8 Treatment Plants | 1 aerated Oxidation Pond<br>7 Trickling Filter | Mainly Agricultural Drains, Some to Land Reclamation | 225.000 |
| **Greater Cairo** | | | |
| Helwan | Activated Sludge | Land Reclamation | 35.000 |
| Berka | Activated Sludge | Agricultural Drain | 600.000 |
| Zenein | Activated Sludge | Agricultural Drain | 330.000 |
| Abu-Rawash | Only Primary Treatment | Land Reclamation | 720.000 |
| **Alexandria** | | | |
| East | Activated Sludge | Lake Mariut | 475.000 |
| West | Activated Sludge | Lake Mariut | 175.000 |
| **Delta Governorates** | | | |
| Zegazig | Activated Sludge | Agricultural Drain | 90.000 |
| Banha | Trickling Filter | Agricultural Drain | 75.000 |
| Shibeen Al-Kawn | Trickling Filter | Agricultural Drain | 74.000 |
| Tanta | Aerated Oxidation Pond | Agricultural Drain | 60.000 |
| Mahalla Kubra | Trickling Filter | Agricultural Drain | 60.000 |
| Kafr Al-Zayat | Activated Sludge | Agricultural Drain | 90.000 |
| Mit Mazah | Oxidation Pond | Agricultural Drain | 75.000 |
| Damietta | Activated Sludge | Lake Manzala | 90.000 |
| Ras El-Bar | Extended Aeration | Mediterranean Sea | 50.000 |
| Dakhla | Oxidation Pond | Agricultural Drain | 62.000 |
| 28 Other Facilities | Oxidation Pond<br>Aerated Oxidation Pond<br>Extended Aeration<br>Oxidation Ditch<br>Trickling Filter<br>Activated Sludge<br>Aqualife | Mainly Agricultural Drains and Lake Manzala | 228.000 |

* Only plants with a capacity > 50.000 $m^3$ / day are listed separately.

Geographical overview of the operational wastewater treatment facilities on the Nile River system is given in Figure 7 and Table 11. Most of the existing wastewater treatment plants in Egypt operate according to the activated sludge process (conventional activated sludge; extended aeration; oxidation ditch), a smaller part are fixed film reactors (trickling filter) and stabilization ponds (oxidation ponds and aerated oxidation ponds). The last sub-type, aerated oxidation ponds are, because of their algae activity, not considered to be secondary treatment. Especially in the Greater Cairo area, high levels of toxic substances in sewage are reported (Taylor Binnie and Partners, 1992).

As those toxic substances (heavy metals, toxic organic substances) will be mainly attached to suspended materials, most of it will be removed by appropriate secondary treatment. Nevertheless, the remaining toxic substances may still contaminate surface waters. Moreover there is no national program in Egypt for sludge disposal. Improper sludge disposal may lead again to contamination of surface and groundwater.

It is worth mention that the total municipal sewage in Egypt is about 3.5 billion cubic meters per annum, which is three times the amount of annual produced rainfall. In addition, the nitrogen content of this amount sewage is estimated at 0.14 million ton. The price of an equal amount of the inorganic fertilizer is $30 million. The net water requirements of cotton and winter wheat are 12,240 $m^3$/ha/season and 10,800 $m^3$/ha/season. Based on the previous data, reuse of domestic sewage in Egypt could add 0.25 million ha of cotton or 0.28 million ha of wheat, which represent 6%-7% of the present 3.9 million ha cultivated area.

**5.4.3.1 Canals and Rayahs**

Water quality monitoring campaigns conducted to date have included irrigation canals to a very limited extent. In general, canals have water quality similar to that at the point of diversion from the Nile. The flow in the canals varies with irrigation demands. Most of these canals are sources for drinking water treatment plants.

Twelve canals and rayahs have been monitored during the February 2001 campaign. Available data indicate that dissolved oxygen, BOD and total solids concentrations in all surveyed canals and Rayahs are within the permissible limits (Table 12). The shaded values in the table denote non-compliance with standards. With regard to COD values, only *El-Lahoun* and *Sako* complied with the standard values. With the exception of Ibrahimia Canal and El-Beherri Rayah, fecal coliform counts in all surveyed canals exceeded the WHO Guidelines (1000 MPN/100 ml). In Monoufi and Nasery Rayahs, the fecal coliform counts were $10^4$ MPN/100 ml. This indicates the presence of human wastes. Heavy metals concentrations in Canals and Rayahs were within the permissible limits.

**5.4.3.2 Agricultural Pollution**

Agriculture is the major non-point source pollution, with a number of potential impacts on the environmental and human health. In many agricultural areas, local surface and groundwater contamination has resulted from leaching of nitrates from fertilizers, and bacteria from livestock and feed wastes. Agricultural pesticides are both a potential diffuse source of water contamination.

The major impacts of agriculture on water quality in Egypt are:

- Increase in salinity,
- Deterioration of quality due to fertilizers and pesticides and;
- Possible eutrophication of water bodies due to an increase in nutrients from fertilization

It is estimated that in Upper Egypt, approx. 4 billion $m^3$ of drainage water returns to the Nile every year. This drainage water has a much higher salinity than the originally ingested irrigation water and contributes to an increase of salinity of the River Nile along its course from the High Aswan Dam to the Delta. Fortunately, the high mixing ratio of Nile and drainage water keeps the increase of salinity within acceptable limits. Salinity increases from 160 mg/l at the High Aswan Dam to 250 mg/l in Cairo.

Table 34:Results of field analysis for canals and Rayahs

| Canal & Rayah | DO | COD | BOD | RDS | TSS | FC |
|---|---|---|---|---|---|---|
| Consent standards | 5 | 10 | 6 | 500 | NA | 1000* |
| Menoufi Rayah | 5.97 | 16 | 3.02 | 225 | 29 | 10000 |
| El-Beherri Rayah | 7.58 | 14 | 1.74 | 220 | 6 | 1000 |
| El Nasey Rayah | 6.71 | 12 | 3.96 | 220 | 16 | 10000 |
| Astoun Canal | 7.03 | 11 | 1.82 | 200 | 8 | 1600 |
| Kelabia Canal | 7.57 | 15 | 1.71 | 205 | 12 | 1500 |
| East Naga Hamadi Canal | 6.31 | 25 | 5.78 | 213 | 9 | 1750 |
| West Nagahamadi Canal | 7.22 | 18 | 4.32 | 200 | 6 | 2500 |
| Ibrahimia Canal (Dairot) | 7.84 | 37 | 3.55 | 200 | 8 | 2000 |
| Ibrahimia Canal (El-Minia) | 8.12 | 23 | 3.08 | 200 | 17 | 650 |
| Ibrahimia Canal (Beni-Suef) | 7.38 | 21 | 2.01 | 230 | 12 | 1500 |
| El-Lahoun | 7.08 | 10 | 1.89 | 305 | 12 | 5000 |
| Sako | 6.98 | 10 | 2.68 | 280 | 40 | 1100 |

* **WHO (1989) Guidelines for Unrestricted Irrigation**

In the Delta, because of the domestic and industrial pollution from Cairo and because of intensive agriculture, salinity in the drainage and irrigation systems further increase; salinity of drainage water discharged into the Mediterranean Sea or the northern Lakes averaged 2260 mg/l. More than half of this drainage water has a salinity < 2,000 mg/l and could be potentially reused for irrigation and drinking water supply after appropriate treatment and mixing. Due to more intensive use, salinity of the discharged drainage water may increase in the next years and re-use of drainage water may become more complicated than before.

With the construction of the High Aswan Dam in 1964, silt deposits on the Nile flood plains have decreased from 24 million tons per year to 2.1 million tons per year. This decrease has been responsible for a significant increase in the use of chemical fertilizers, resulting in increased values of nutrients in canals and drains.

### 5.4.3.3 Agricultural Drains

According to the National Water Resources Plan for Egypt (NWRP 2001), the Nile River from Aswan to Delta Barrage receives wastewater discharge from 124 point sources, of which 67 are agricultural drains and the remainder is industrial sources. Figures (2, 3) show the industrial and the agricultural drain outfall points schematically.

**Drains in Upper Egypt and South Cairo.**

Physico-chemical characteristics and faecal coliform counts of 43 major drains at the tail ends, before discharge into the Nile are presented in Table 13. The parameters that are non-compliant with Law 48 are shown shaded in the table. The data indicates that out of the 43 drains, only 10 are complying with the standards set by Law 48/1982 (Article 65) regulating the quality of drainage water, which can be mixed with fresh water. This is demonstrated graphically in Figures (7 and 8) for selected parameters. The remainder of the drains exceeds the consent standards in one or more of the parameters. The worst water quality is that of Khour El-Sail Aswan, Kom Ombo, Berba and Etsa drains.

In terms of organic load, it was found that the highest organic load is discharged from Kom Ombo drain (218.1 ton COD/d, 59.7 ton BOD/d). This is followed by El-Berba drain (172.7 ton COD/d; 59.7 ton BOD/d), (Table 13). The shaded values highlight the drains that are the worst cases by far. It is worth mentioning that these two drains contribute 76% of the total organic load (calculated as COD) discharged into the Nile by drains from Aswan to Delta Barrage. This is followed by Etsa drain which contributes about 11% of the total COD load (56.8 ton COD/d).

**Drains in the Delta**

Delta drains are mainly used for discharge of predominantly untreated or poorly treated wastewater (domestic and industrial), and for drainage of agricultural areas. Therefore, they contain high concentrations of various pollutants such as organic matter (BOD, COD), nutrients, faecal bacteria, heavy metals and pesticides.

The drainage water is becoming more saline; on average its salinity increased from 2400 $g/m^3$ in 1985 to 2750 $g/m^3$ in 1995. But there are local variations. For example, in the southern part of the Nile Delta drainage water has salinity between 750 and 1000 $g/m^3$, whereas the salinity in the middle parts of the Delta reaches about 2000 $g/m^3$ and in the northern parts between 3500 and 6000 $g/m^3$.

In a recent study published by DRI (2000), it has been estimated that the Delta and Fayoum drains receive about 13.5 BCM/year. Almost 90% of which is contributed from agricultural diffuse source, 6.2% from domestic point sources, 3.5% from domestic diffuse sources and the rest (3.5%) from industrial point sources. It was also found that Bahr El-Baqar receives the greatest part of wastewater (about 3 BCM/year). This is followed by Bahr Hados, Gharbia, Edko and El-Umoum, with an average flow of 1.75 BCM/year for each. The wastewater received by the rest of the drains is less than 0.5 BCM/year for each.

In terms of organic loads, as expressed by COD and BOD values, Bahr El-Baqar drain receives the highest load followed by Abu-Keer drain. Also, El-Gharbia Main receives significant amounts of organic pollutants.

Table 35: Loads of organic and inorganic pollutants into the Nile from Upper Egypt drains.

| No. | Drain Name | Location (KM) | Discharge mm3/day | COD mg $O_2$/l | BOD mg $O_2$/l | DO mg$O_2$/l | TDS mg/l | FC MPN/100ml | Heavy Metals |
|---|---|---|---|---|---|---|---|---|---|
| | Consent Standard | | | 15 mg/l | 10 mg/l | 5 mg$O_2$/l | 500 mg/l | 5.00E+03 | 3 |
| 1 | Khour El sail Aswan | 9.9 | 0.10 | 102 | 32.80 | 1.91 | 1190 | 3.25E+04 | 0.31 |
| 2 | El Tawansa | 37.3 | 0.01 | 8 | 1.01 | 6.16 | 710 | 3.50E+03 | 0.50 |
| 3 | El Ghaba | 46.6 | 0.19 | 11 | 1.00 | 7.8 | 570 | 1.85E+03 | 0.75 |
| 4 | Abu Wanass | 47.2 | 0.20 | 7 | 1.28 | 7.03 | 463 | 3.00E+03 | 0.39 |
| 5 | Main Draw | 48.9 | 40 l/s | 17 | 1.48 | 7.34 | 460 | 3.00E+04 | 0.61 |
| 6 | El Berba | 49.1 | 0.15 | 113 | 42.70 | 3.85 | 414 | 2.25E+04 | 0.70 |
| 7 | Com Ombo | 51.0 | 0.14 | 151.6 | 41.50 | 2.25 | 325 | 2.25E+04 | 2.15 |
| 8 | Menaha | 55.0 | - | 4 | 1.52 | 7.86 | 285 | 7.50E+03 | 0.26 |
| 9 | Main Ekleet | 57.0 | 0.02 | 4 | 1.53 | 9.21 | 340 | 1.50E+03 | 2.44 |
| 10 | El Raghama | 64.7 | 0.04 | 10 | 1.55 | 8.56 | 390 | 1.75E+03 | 0.30 |
| 11 | Fatera | 70.5 | 0.78 | 5 | 2.04 | 7.7 | 564 | 3.50E+03 | 0.54 |
| 12 | Khour El sail | 70.8 | 0.17 | 2 | 1.05 | 9.07 | 500 | 2.00E+03 | 0.34 |
| 13 | Selsela | 73.9 | 50 l/s | 3 | 1.25 | 6.38 | 380 | 3.20E+03 | 1.26 |
| 14 | Radisia | 99.9 | 0.13 | 16 | 3.06 | 9.02 | 1430 | 2.30E+03 | 0.22 |
| 15 | Edfu | 116.2 | 0.27 | 15 | 1.59 | 9.49 | 817 | 3.00E+03 | 2.37 |
| 16 | Houd El Sebaia | 139.5 | 0.05 | 16 | 1.83 | 6.77 | 495 | 1.75E+04 | 0.76 |
| 17 | Hegr El Sebaia | 149.1 | 0.05 | 19 | 2.55 | 7.82 | 670 | 4.50E+03 | 0.51 |
| 18 | Mataana | 187.7 | 0.12 | 39 | 3.15 | 6.45 | 613 | 1.75E+04 | 1.29 |
| 19 | El Zeinia | 236.0 | NA | NA | NA | * | * | * | NA |
| 20 | Habil El Sharky | 237.7 | 0.08 | 30 | 1.78 | 8.45 | 560 | 4.00E+02 | 1.06 |
| 21 | Danfik | 251.6 | 0.01 | 34 | 2.52 | 8.51 | 367 | 1.50E+03 | 1.05 |
| 22 | Sheikia | 265.3 | 0.06 | 37 | 1.72 | 7.55 | 662 | 3.75E+03 | 4.68 |
| 23 | El Ballas | 270.7 | 0.01 | 144 | 10.78 | 9.17 | 1395 | 1.50E+04 | 0.59 |
| 24 | Qift | 275.9 | 0.03 | 30 | 1.60 | 9.11 | 375 | 2.50E+03 | 0.39 |
| 25 | Hamed | 331.2 | 0.07 | 11 | 1.00 | 7.18 | 1015 | 9.00E+02 | 0.35 |
| 26 | Magrour Hoe | 340.4 | 0.06 | 21 | 3.24 | 8.2 | 185 | 1.60E+03 | 1.05 |
| 27 | Naga Hammadie | 377.8 | 0.21 | 13 | 2.17 | 8.11 | 375 | 3.30E+03 | 1.67 |
| 28 | Mazata | 392.8 | 0.01 | 10 | 2.19 | 8.37 | 495 | 2.50E+02 | 0.23 |
| 29 | Essawia | 432.7 | 0.07 | 9 | 2.43 | 6.61 | 200 | 1.50E+03 | 0.51 |
| 30 | Souhag | 444.6 | 0.05 | 9 | 2.81 | 7.42 | 440 | 8.00E+02 | 0.38 |
| 31 | Tahta | 486.4 | 0.01 | 21 | 2.01 | 7.86 | 980 | 1.40E+03 | 0.29 |
| 32 | El Badary | 525.4 | 0.12 | 6 | 3.27 | 7.25 | 255 | 9.00E+02 | 0.48 |
| 33 | Bany Shaker | 588.6 | 0.02 | 13 | 2.25 | 7.47 | 485 | 1.00E+04 | 0.30 |
| 34 | El Rayamoun | 637.4 | NA | 21 | 15.85 | 2.77 | 290 | 1.50E+03 | 0.16 |
| 35 | Etsa | 701.2 | 0.57 | 100 | 38.00 | 1.58 | 575 | 3.50E+04 | 0.19 |
| 36 | Absoug | 780.5 | 0.19 | 29 | 1.89 | 7.34 | 640 | 3.00E+03 | 0.34 |
| 37 | Ahnasia | 807.2 | 0.54 | 14 | 1.31 | 7.08 | 610 | 3.75E+03 | 0.26 |
| 38 | El Saff | 871.3 | NA | NA | NA | * | * | * | NA |
| 39 | El Massanda | 879.6 | 0.14 | 45 | 4.99 | 5.57 | 715 | 3.00E+03 | 0.19 |
| 40 | Ghamaza El Soghra | 884.5 | 0.06 | 42 | 2.52 | 6.37 | 235 | 9.50E+02 | 0.46 |
| 41 | Ghamaza El Kobra | 885.0 | 0.05 | 32 | 3.79 | 7.39 | 290 | 7.50E+02 | 0.28 |
| 42 | El Tibeen | 898.1 | 0.02 | 25 | 15.20 | 3.71 | 840 | 3.25E+04 | 0.39 |
| 43 | Khour Sail Badrashin | 910.2 | NA | NA | NA | * | * | * | NA |

: Not complying

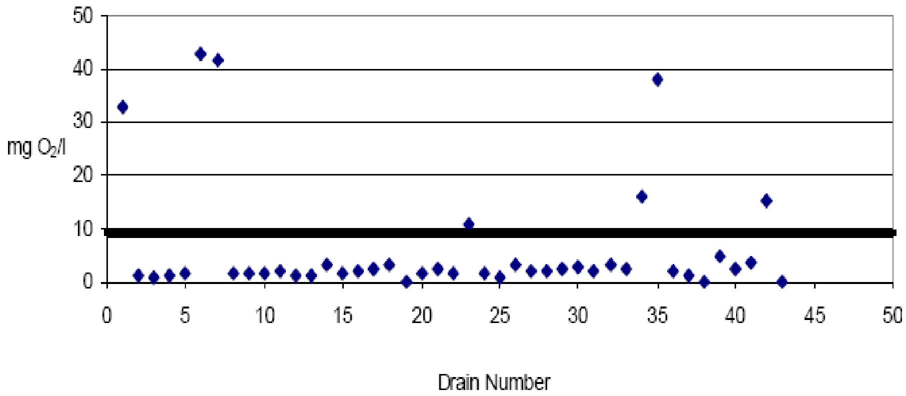



Fig. 12 COD values of Upper Egypt drains at their points of discharge into the Nile

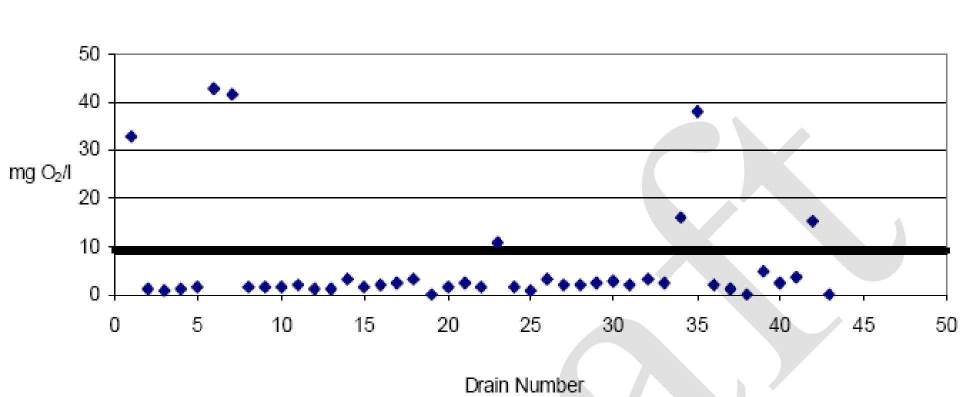



Fig. 13: BOD values of Upper Egypt drains at their points of discharge into the Nile.

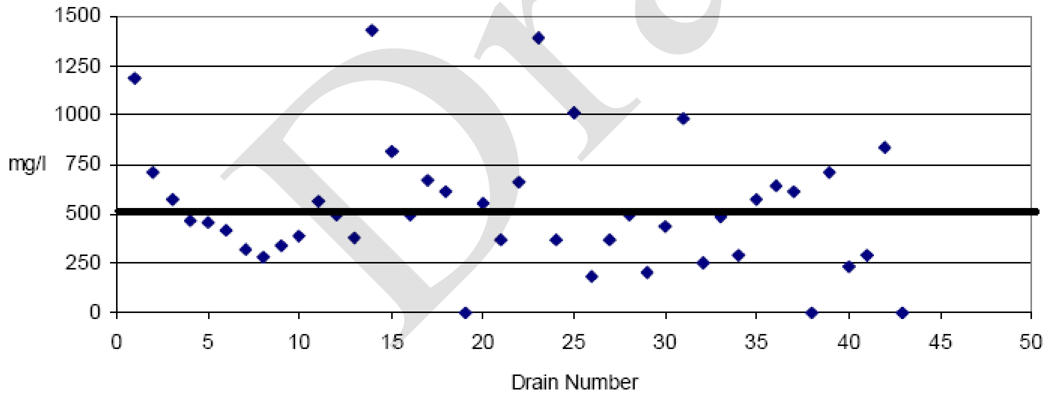



Fig. 14: TDS values of Upper Egypt drains at their points of discharge into the Nile.

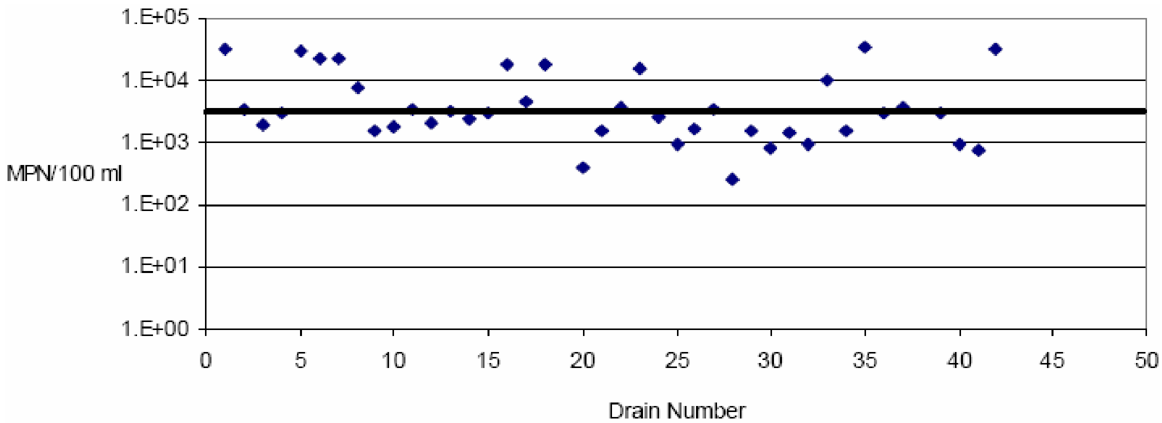



Fig. 15: FC counts in Upper Egypt drains at their points of discharge into the Nile.

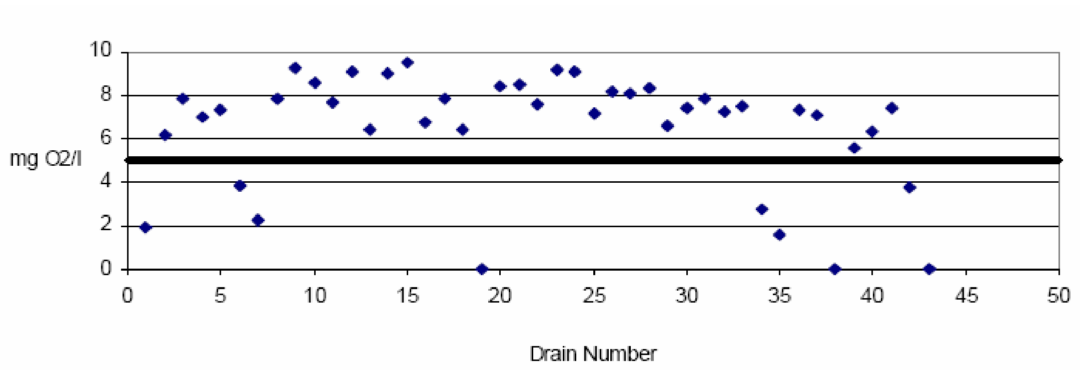



Fig. 16: DO concentrations of Upper Egypt drains at their points of discharge into the Nile.

*Source (Fig 13-17): Monitoring Campaign by MWRI, 2001*

Table 36: Loads of organic and inorganic pollutions in to the Nile From Upper Egypt

| No. | Drain Name | Location (KM) | Discharge mm3/day | COD kg/day | BOD kg/day | Heavy metals kg/day |
|---|---|---|---|---|---|---|
| 1 | Khour El sail Aswan | 9.9 | 0.098837 | 10.08137 | 3.241854 | 0.030333075 |
| 2 | El Tawansa | 37.25 | 0.006484 | 0.051872 | 0.006549 | 0.003245242 |
| 3 | El Ghaba | 46.55 | 0.194087 | 2.134957 | 0.194087 | 0.146341598 |
| 4 | Abu Wanass | 47.15 | 0.199061 | 1.393427 | 0.254798 | 0.078330504 |
| 5 | Main Draw | 48.85 | 0.003456 | 0.058752 | 0.005115 | 0.002106432 |
| 6 | El Berba | 49.1 | 0.15282 | 172.6866 | 65.25414 | 0.10720323 |
| 7 | Com Ombo | 51 | 0.143865 | 218.0993 | 59.70398 | 0.309122726 |
| 8 | Menaha | 55 | NA | 0 | 0 | 0 |
| 9 | Main Ekleet | 57 | 0.020166 | 0.080664 | 0.030854 | 0.049174791 |
| 10 | El Raghama | 64.65 | 0.044712 | 0.44712 | 0.069304 | 0.013346532 |
| 11 | Fatera | 70.45 | 0.779492 | 3.89746 | 1.590164 | 0.418197458 |
| 12 | Khour El sail | 70.75 | 0.170387 | 0.340774 | 0.178906 | 0.058016774 |
| 13 | Selsela | 73.85 | 0.00432 | 0.01296 | 0.0054 | 0.005454 |
| 14 | Radisia | 99.85 | 0.1307 | 2.0912 | 0.399942 | 0.02908075 |
| 15 | Edfu | 116.2 | 0.2689 | 4.0335 | 0.427551 | 0.63742745 |
| 16 | Houd El Sebaia | 139.5 | 0.048989 | 0.783824 | 0.08965 | 0.037256135 |
| 17 | Hegr El Sebaia | 149.1 | 0.049541 | 0.941279 | 0.12633 | 0.02524114 |
| 18 | Mataana | 187.7 | 0.122499 | 4.777461 | 0.385872 | 0.158207459 |
| 19 | El Zeinia | 236 | NA | 0 | 0 | 0 |
| 20 | Habil El Sharky | 237.7 | 0.079119 | 2.37357 | 0.140832 | 0.084222176 |
| 21 | Danfik | 251.55 | 0.008224 | 0.279616 | 0.020724 | 0.00865576 |
| 22 | Sheikia | 265.3 | 0.05983 | 2.21371 | 0.102908 | 0.279794995 |
| 23 | El Ballas | 270.7 | 0.006383 | 0.919152 | 0.068809 | 0.003788311 |
| 24 | Qift | 275.9 | 0.032637 | 0.97911 | 0.052219 | 0.012744749 |
| 25 | Hamed | 331.2 | 0.067068 | 0.737748 | 0.067068 | 0.023239062 |
| 26 | Magrour Hoe | 340.35 | 0.058709 | 1.232889 | 0.190217 | 0.061497678 |
| 27 | Naga Hammadie | 377.8 | 0.2149 | 2.7937 | 0.466333 | 0.35920535 |
| 28 | Mazata | 392.75 | 0.005868 | 0.05868 | 0.012851 | 0.001329102 |
| 29 | Essawia | 432.7 | 0.074202 | 0.667818 | 0.180311 | 0.037731717 |
| 30 | Souhag | 444.55 | 0.0475 | 0.4275 | 0.133475 | 0.01826375 |
| 31 | Tahta | 486.4 | 0.006276 | 0.131796 | 0.012615 | 0.001829454 |
| 32 | El Badary | 525.4 | 0.11994 | 0.71964 | 0.392204 | 0.05703147 |
| 33 | Bany Shaker | 588.6 | 0.019602 | 0.254826 | 0.044105 | 0.005968809 |
| 34 | El Rayamoun | 637.4 | NA | 0 | 0 | 0 |
| 35 | Etsa | 701.15 | 0.567976 | 56.7976 | 21.58309 | 0.105359548 |
| 36 | Absoug | 780.5 | 0.194386 | 5.637194 | 0.36739 | 0.066965977 |
| 37 | Ahnasia | 807.2 | 0.541652 | 7.583128 | 0.709564 | 0.138933738 |
| 38 | El Saff | 871.3 | NA | 0 | 0 | 0 |
| 39 | El Massanda | 879.6 | 0.14148 | 6.3666 | 0.705985 | 0.02624454 |
| 40 | Ghamaza El Soghra | 884.5 | 0.059616 | 2.503872 | 0.150232 | 0.027214704 |
| 41 | Ghamaza El Kobra | 884.95 | 0.048036 | 1.537152 | 0.182056 | 0.013618206 |
| 42 | El Tibeen | 898.1 | 0.02017 | 0.50425 | 0.306584 | 0.007795705 |
| 43 | Khour Sail Badrashin | 910.15 | NA | 0 | 0 | 0 |
| sum | | | | 516.6321 | 157.8541 | 3.449520092 |

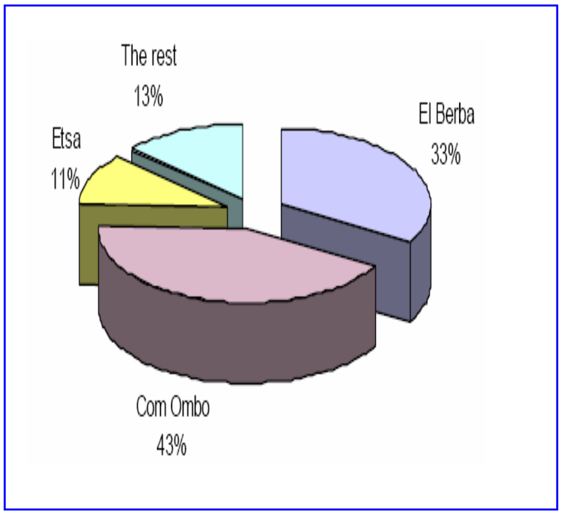



Fig. 17: COD loads contributed by the agricultural drains from Aswan to delta barrage.

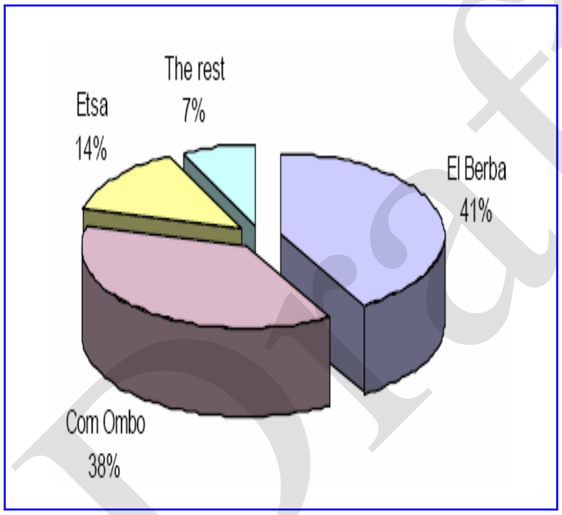



Fig. 18: BOD loads contributed by the agricultural drains from Aswan to delta barrage (*Source: Fig 12 and 13: MWRI, 2001*



**5.4.3.4 Pesticides used in Egypt**

In Egypt, as in many other agricultural countries, pesticides are widely used to control harmful pests, mainly, cotton, maize, and rice. Pesticides in Egypt are different types such as organochlorine, organophosphorus, cabamates, urea, anilides and pyreethroid. The four general categories of pesticides are herbicides, insecticides, fungicides and bactericides. Herbicide control unwanted vegetation, insecticides kill insects, fungicides destroy fungi and bactericides are lethal to bacteria.

**Insecticides**

Concern over the environmental and health effects related to pesticides use in the $1950_s$ with the organochlorine insecticides, including DDTs, lindane, endrin and other organochlorine, insecticides, which were used extensively for agricultural control of insects until 1982. These groups are characterized by long persistence in the environment and bioaccumulation in fatty tissues. More than 13,000 tones of DDT, 45,000 tones of toxaphene, 10, 500 tones of endrine and 11, 300 tones of lindane were used in Egypt in the period between 1952 and 1981 (El-Sebae 1982).

Organophosphorus insecticides, such as dimethoate, diazinon monocrotophos, fenitrothion, chloropyriphos and formathion, are of great significance in pest control and increasingly used instead of organochlorine insecticides. Organophosphorus insecticides represent more than 80% of total insecticides used in Egypt during 2000. These compounds are much less persistent in the environment (Aly and Badawy, 1984) but are toxic to non- target creatures such as aquatic organisms, birds and some beneficial insects.

Among more developed insecticides used in Egypt are carbamates and synthetic pyrethroid. The carbamates are substituted esters of carbamic acid. Their advantage over other kinds of pesticides formerly used stems from the fact they are more biodegradable than the organochlorine compounds and are less toxic to mammals than organophosphorus pesticides. However, some carbamates are highly toxic such as aldicarb (LD50 1 mg/kg) and some others are suspected carcinogens and mutagens (Njagi and Gopalan 1980).

Aldicarb and methomyl are widely used in Egypt as carbomate insecticides. These compounds and their metabolities are highly soluble in water (Miles and Delfino 1984), and their stability under certain environmental conditions has made them serious threat to drinking water (Lemely and Zhong 1984). Aldicarb is systemic pesticide, applied directly to plant roots so that upon irrigation it can easily leach into groundwater (Jones 1986).

**Fungicides**

Fungicides account for 65.5% of pesticides used in Egypt; agricultural use constitutes the majority of applications. Fungicides used are mainly inorganic, and include 593.7 tones Cu oxychloride and 9118.8 tones sulphur. However, the amount of total organic compounds used as fungicides was 1786.1 tones. Captan, chlorothalonal, moncozeb, Malathion, metalaxy and thiophenoate are among the most used organic fungicides. Among the crops requiring fungicide treatment are potatoes, tree fruits and berries. Fungicides containing the active ingredients mancozeb and chlorothalonil are commonly used in potato and orchards fields. Grapes and strawberries are treated with thiophanate- methyl.

**Herbicides**

Herbicides account for less than 4% of the pesticides used in Egypt. Among the most used compounds are atrazine, glyphosate, bromoxynil and furon. Herbicides are used to control weeds and to kill the tops of potato plants before harvest. The use of herbicides has dropped since the early $1990_s$ and the phenoxy compounds, 2, 4-D and 2, 4, 5-T, were replaced by atraizne and glyphosate herbicides. The total amount of herbicides reduced from 1352.5 tones while in 2000 it was 584.7 tones.

In 1952 the total usage of pesticides was only 2000 tones. Since then, pesticides use has been increased to reach its maximum in 1975 (Table 15). Starting from 1980 a shift was made to shorter- acting materials. The idea of controlling pests and vectors by biological programmes as an alternative to chemicals or in combination with pesticides becomes realized. Therefore, chemical pesticides use has been steadily declining.

Table 37: Amount of pesticides and chemical fertilizers used in Egypt

| Year | Pesticides (tons) | Chemical fertilizer (1,000 tons) |
|---|---|---|
| 1952 | 2,100 | 730 |
| 1960 | 16,300 | 1,400 |
| 1965 | 25,100 | 2,150 |
| 1970 | 25,600 | 2,450 |
| 1975 | 27,400 | 5,750 |
| 1980 | 20,500 | 4,500 |
| 1985 | 18,400 | 5,900 |
| 1990 | 17,200 | 6,240 |
| 1995 | 16,435 | 6,395 |
| 2000 | 6,500 | - |

In the Last few years, a significant decrease in pesticide consumption has taken place. In 2000, only 6,500 tones of pesticides were used, compared to 16,400 tones used in 1995. The decrease was largely the result of integrated pest management program (IPM).

Table 38 Commonly used pesticides in Egypt

| Item | Amount of formulated Materials (tons) |
|---|---|
| Organophosphorus insecticides | 1,950 |
| Carbamate insecticides | 550 |
| Synthetic pyrethroids insecticides | 800 |
| Photoxin | 100 |
| Acaricide( Kelthane) | 500 |
| Rodenticides | 1,500 |
| Fungicides | 593 |
| Herbicides | 584 |

#### 5.4.3.5 Pesticides Residues in the River Nile system

***River Nile***

Beta HCH, lindane, aldrin, dieldrin, heptachlor, endrin, p,p'DDT, and its analogous were detected in the River Nile (Table 16). The highest detected level of DDTs was at Aswan Dam, reaching 1.048 ug/l, which is considered slightly above World Health Organization and Egyptian guidelines of 1 ug/l in the drinking water. The highest concentration of total organochlorine insecticides was found 7.5 km up-stream of Aswan (2.275 ug/l).

High concentration of p, p'DDT in water samples taken from upstream of Aswan sites indicated to a recent application of the product by some upstream countries. In general, levels of organochlorine insecticides in River Nile water are still within safety margins, compared to the permissible limits for drinking waters (WHO 1984).

The residue levels of organochlorine insecticides and PCBs in water and sediment samples collected from River Nile were determined. Seven sites were selected to represent different regions in Delta Nile and El-Rayah El-Beheiri. These sites are Delta Barrage at Cairo Kafr El-Ziate, Desouk, Edfina, Rosetta, El-Mansora and Demitta. Kafr El-Ziate was the most polluted location showing 1495 ng/l for water and 7.4 mg/kg for sediment. However, at Rosetta, which is down stream with respect to Kafr El-Ziate, the total concentration of organochlorine insecticides and PCBs (GT) was decreased to reach 473.98 ng/l for water and 3.8mg/kg for sediment (Abdalla, 1989).

The levels of organochlorine insecticides had been monitored in Tilapia fish collected from different locations in the River Nile and two canals. BHC, lindane, DDT and its metabolites were identified and quantified. Fish samples collected from El-Mahmodia and Abo El-Gheit canals were found to contain higher levels of organochlorine insecticides than samples collected from River Nile (Table 16). This may be due to the pollution of these canals by pesticides as they are located in agricultural areas, subjected to the application, and leaching of pesticides. Data in Table 17 showed that p, p' DDT and its metabolites were predominant in fish samples collected from Manzala Lake and River Nile. Also, the results demonstrated that fish samples from both locations are contaminated with low levels of OCI and PCBs.

***Drains and Irrigation Canals***

Drains are of concern because their water is reused for irrigation and drainage water from pesticide-treated land is pumped into major drains that finally discharge their waters into the River Nile. It was estimated that 4 billion $m^3$ of drainage water from agricultural drains returns to the River Nile or Lakes (Welsh and Mancy, 1992). El-Serw and Hadous drains are of significance as they play a major role in north Sinai development project. Water from two drains will mix with the Nile River at Dimitta branch at 1:1 ratio to go to El-Salam canal. The highest amount of total DDTs was found in Hadous drain and it reached 451ng/l. The mean concentration for lindane and PCBs was 7.6 and 14.5 ng/l, respectively (Badawy et. al., 1995).

A study of drains in 1991 showed that DDT and its metabolites were common at all locations, reaching the maximum in the Delta regions and the minimum in the pesticides factory out- fall.

The highest level of DDTs was detected after winter closure period in Delta Barrage.The residues of organochlorine insecticides in Upper Egypt drains were evaluated and Beta -HCH, lindane, heptachlorepoxide, DDT and its metabolites were detected in all water and sediment samples. However, aldrin and dieldrin were not detected. DDTs were predominating components in the samples, reaching the highest concentration (1553.6ng/l) in water samples collected from the Desamy drain and 36.56mg/kg in sediment samples from the Etsa drain.

Little information is known about canal pollution with pesticides in Egypt. However, canals are probably polluted with pesticides that come from land use, spray drift, washings of spraying equipment, or from River Nile.

Ismaillia and El-Mahmodia canals are the main sources for drinking purposes and irrigation in the Suez Canal area and Alexandria. PCBs have been identified and quantified in two canals. The maximum concentration (77 ng/l) was detected in the samples collected from Ismaillia canal. In El-Mahmodia canal, the main source of drinking water supply in Alexandria, organochlorine insecticides have been measured in water and fish samples. Water analysis results indicated that the average concentration of lindane and its isomers ranged from 0.39 to 6.26ng/l. However, the average concentration of p,p' DDT and its metabolites ranged from 1.2 to 30.8ng/l. The maximum concentrations of heptachlor, and heptachlorepoxide were 0.12 and 0.65 ng/l, respectively. These results indicate that organochlorine insecticides residues are far below WHO guideline (1984).

Table 39: Quantity of the Most Frequently Used Pesticides, Applied in the Different Governorates

| **Governorate** | **Pesticides used (ton/year)** | | | | | **Cropping Area 1000 feddan)[(1)]** | **Intensity of use (kg/ feddan)** |
|---|---|---|---|---|---|---|---|
| | **Mancozeb** | **Malathion** | **Dimethoate** | **Cblorp-yrophos** | **Methomyl** | | |
| Aswan, Qena, Souhag | 44 | 58 | 24 | 55 | 11 | 713 | 0.27 |
| Assiut, Minia, Beni Sueif | 176 | 37 | 127 | 36 | 60 | 853 | 0.51 |
| Fayoum | 55 | 26 | 36 | 26 | 16 | 379 | 0.42 |
| Giza, Cairo | 58 | 70 | 27 | 68 | 18 | 183 | 1.32 |
| Qalubiya | 58 | 28 | 19 | 27 | 10 | 299 | 0.47 |
| Minufiya | 76 | 36 | 43 | 35 | 27 | 380 | 0.57 |
| Sharqiya | 150 | 43 | 79 | 42 | 35 | 860 | 0.41 |
| Beheira | 219 | 91 | 154 | 88 | 79 | 928 | 0.68 |
| Other governorates Delta | 108 | 77 | 57 | 76 | 32 | 1.050 | 0.33 |
| Total | 944 | 644 | 566 | 453 | 288 | 5.645 | 0.48 |

[1] *Net Cropping Area of the Considered Crops*

***Coastal Lakes***

The distribution and residue levels of BHC, lindane, endrine, p, p'DDT and its metabolites in Mugil and Tilapia species collected from Egyptian Delta lakes were evaluated (Table 16). Residues of BHC and p,p'DDT were found in all fish samples collected from four lakes. The high levels of p,p'DDT and p,p'DDD in fish samples is an indication of recent application of DDT. The order of mean concentration for total organochlorine insecticides tends to be Edku (39.03-61.44)> Maryut (28.57-38.78)> Manzala (22.40-25.13)> El-Borullus (8.82-39.02), results are represented in ug/kg wet weight. The order is a function of the amount of pesticides received by the lakes, their area, and their ability to exchange their water. Edku Lake has no access to the Mediterranean Sea and receives both municipal and agricultural wastewater. Maryut Lake though linked with the sea and has the smallest area as compared with other lakes. Manzala

Lake, which is located in the most productive agricultural region of the Nile Delta, receives municipal and agricultural wastewater. However, the lake exchanges its water with the Mediterranean Sea and Suez Canal, and receives fresh water from its associated canals. Hence, the dilution effects and the extended area of the lake tend to decrease the concentration of residues. El-Burullus Lake has direct access to the Sea is located in a less developed agricultural region, and its area comes next to that of Manzala Lake (Badawy and El-Dib, 1984).

With regard to residual pesticide concentrations in lake Manzala, analysis carried in 1990 (UNEP, 1992) indicated the presence of BHC, heptachlor, aldrin, p,p'DDT and its metabolites. The highest concentration was that of p, p' DDE which ranged between 18.2 and 173.3 ng/l, with an average value of 76.87 ng/l. Average concentration of Malathion (organophosphours insecticides) was 425 ng/l.

A recent survey carried out by Badawy and Wahaab (1997) confirmed that the concentration of p, p'DDE in sediment samples in Manzala area near the major drains is rather high. This implies that: (1) the situation may have been worse in the past when DDT was more frequently applied, or (2) The drainage channels may assist the degradation of p, p' DDT to its anaerobic degradation product p,p'DDE prior to discharge into the Lake.

The concentration of chlorinated insecticides and PCBs in fish and sediment are generally low in samples collected from Lake Manzala area. Therefore, the health risk from chlorinated hydrocarbons is insignificant. The most significant contamination was observed in the samples collected from the lake near the major drains. Referring to the FAO/WHO acceptable daily intake (ADI) can assess the public health implication of fish contamination by the chlorinated hydrocarbons. The percentage of ADIs for lake Manzala fish ranged from 0.02% to 4.8% and the public is not at risk from fish consumption, even if totally dependent upon fish as a protein source (Badawy 1998).

Organophosphrous pesticides have rapidly replaced the persistent organochlorine compounds for most pest control purposes. Some of the organophosphours pesticides however, are present in the marine environment for an appreciable period of time, particularly associated with sediments. They are usually characterized by a very high specific toxicity but for the most part of aquatic environment, they are not readily accumulated in living tissue. They are normally therefore, associated with events of acute toxicity (fish kills) or cause a weakening of critical metabolic processes (cholinesterase inhibition).

The measurement of several OP pesticides in the sediments of Lake Manzala reveals a previously unsuspected threat to the environment. Levels of these compounds are quite low but there is still insufficient information in the scientific literature to link dose/effect relationships. It is impossible to evaluate whether the measured concentrations pose a threat to the environment.

Their presence, however, gives some cause for concern as they may reflect sporadic discharges to the aquatic environment through the drains. Such discharge could cause fish kills. There are also unconfirmed reports that fishermen in the region occasionally employ Alathion or other compounds as a poison for catching fish with pesticides from agricultural drains.

Table 40: Organochlorine Insecticides and PCBs in River Nile and branches

| **Sampling Site** | **ng/L** | | | | | |
|---|---|---|---|---|---|---|
| | **SHCH** | **SHCBs** | **SDDTs** | **Cyclodiene** | **EOCs** | **PCBs** |
| Lake Nasser | 650.46 | 81.30 | 841.47 | 20.86 | 1594.1 | 59.86 |
| Aswan | 220.36 | 36.66 | 1048.24 | 28.50 | 1333.8 | 56.38 |
| Kom Ombo | 187.71 | 31.16 | 1035.25 | 41.27 | 1295.4 | 85.65 |
| Esna | 177.62 | 32.20 | 586.3 | 75.37 | 871.49 | 15.65 |
| Naga Hamady | 123.16 | 24.56 | 297.72 | 40.65 | 486.09 | 32.84 |
| Assiut | 143.65 | 28.37 | 100.56 | 75.28 | 247.86 | 58.46 |
| El-Minia | 163.76 | 30.35 | 82.42 | 16.77 | 293.30 | 28.58 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Beni Suef | 285.40 | 42.85 | 56.83 | 26.50 | 411.58 | 25.30 |
| Delta Barrage | 22.00 | 10.00 | 2.65 | 29.75 | 64.40 | 8.28 |
| Kafer-El-Ziate | 249.34 | 49.65 | 29.75 | 415.37 | 744.16 | 652.84 |
| Dessouk | 166.27 | 53.56 | 37.21 | 186.82 | 443.86 | 295.46 |
| Edfina | 107.26 | 77.80 | 10.133 | 228.11 | 423.30 | 71.76 |
| Rosetta | 185.87 | 16.70 | 98.51 | 32.39 | 333.42 | 140.52 |
| El-Mansoura | 151.01 | 92.61 | 102.67 | 48.43 | 394.72 | 32.43 |
| Demietta | 26.12 | 3.90 | 90.87 | 65.57 | 186.46 | 73.66 |

∑ HCHs = α, ß and ¥ HCH
∑HC ßs = α, ß and ¥ HCB
∑OCs = Total organochlorine insecticides
∑DDTs = P, P' DDE + P, P' DDD +P, P'-DDT
∑ Cyclodiene = P, P' heptachlor + P, P' aldrin + heptochlorepoxide
*Source: Wahaab, R.A. and Badawy, M.B. (2004).*

**5.4.3.6 Fertilizer**

Very little information could be made available on fertilizer use and its partition over different crops and/or governorates other than that of the total amount of fertilizers used

in Egypt that amounts to approximately. 6.5 million tons/year. The excess use of fertilizer and the eventual leaching of fertilizer towards surface and groundwater have been further studied. The pollution potential of fertilizers use can be best demonstrated from the fact that if 10 % of the fertilizer leaches to the agricultural drains, drainage water salinity would increase with approx. 50 mg/l. This does not seem dramatic. However, fertilizer mostly consists of nitrates and phosphates, which in concentrations of around 50 mg/l cause severe eutrophication problems in drainage canals and other water bodies that indirectly receive drainage water. Excessive use of chemical fertilizers persisted due to agriculture production intensification and attempts to reach the highest production possible/unit area. Usage rates of fertilizers have soared compared to international rates. This has led to increased concentration of nutritious elements in drainage water leading to the eutrophication of irrigation and drainage water and the pollution of Northern lakes. Soil and water pollution has also increased due to the irrationalised use of different pesticides. In addition, wastewater and industrial drainage leakage into watercourses has exacerbated soil and water resource pollution.

**5.4.3.7 Salinity**

The salinity measurements made by (Drainage Research Institute (DRI) in the Delta show that closer to the Mediterranean Sea, salinity in the drainage water increases, to reach level close to 10,000 mg/l close to the coast. Although part of the salinity increase may be caused by leaching of salts from the soil, it is believed that most of this increase is caused by upward seepage of brackish groundwater. This theory is supported by observations from DRI and RIGW with regard to chemical composition (major ions) of adjacent drainage and ground water.

In the context of water quality management, agriculture must be seen as a widespread non-point source of pollution. Pollutants include leached salts, nutrients like nitrogen and pesticides. These non-point sources will be collected in agricultural drains to form point sources of pollution for the River Nile, lakes and irrigation canals. Although there are different mechanisms for retaining the pollutants by passing the polluted water through soil, the non-point sources of pollution may influence the groundwater quality.

It is estimate that because of irrigation in Upper Egypt, nearly 2.3 $Bm^3$ of drainage water is returned to the Nile annually, either directly or indirectly. This means that total soluble salt concentration of the Nile is higher inl Lower Egypt (250ppm) as compared to Upper Egypt (180-200ppm) (Abu Zeid, 1988)-(Fig.11). Fortunately, because of the high dilution effect of the Nile, this increase in salt concentration is not significant in terms of any type of possible water use.

The salt affected soils in Egypt are located in the north, east and west of Nile Delta, soils adjacent to lakes Edko, Maryut, El-Burrullus and El Manzala; and also in some areas such as Wadi El-Natrun, Oases and El-Fayoum. This is mainly due to the wide use of flood irrigation and unaccounted-for water usage, water irrigation from the Nile is exaggerated leading to soil water logging and poor drainage of excessive water that exceeds the growing plants needs. Thus, soil salinity components reach a level causing damage to plant production and deterioration to some of the chemical and biological soil elements. Some lands become so rich in soda due to the increase in sodium element causing more degradation in physical elements. During the seventies, sedimentary soil area affected by salinity and soda was estimated to be 30 to 35% of the total Nile valley and Delta area (State of Environment Report, 2005).

#### 5.4.3.8 Assessment of Ambient Water Quality Status

Generally speaking, water released from Lake Nasser generally exhibits the same seasonal variation and the same overall characteristics from one year to another. Downstream changes in river water quality are primarily due to a combination of land and water use as well as water management interventions such as:

- Different hydrodynamic regimes regulated by the Nile barrages,
- Agricultural return flows, and
- Domestic and industrial waste discharges, including oil and wastes from passenger and riverboats.

***River Nile from Aswan to Delta Barrage***

***Chemical Contamination:*** From the available data, the following can be concluded that Dissolved Oxygen Concentration (DO) situation is not alarming. Specific “hot spots”could not be detected. In all monitored sites, DO concentrations were higher than 7.0 mgO2/l, indicating the high assimilation capacity of the Nile. Chemical Oxygen Demand (COD) values showed slight, but steady increase from south to north. 21 samples out of the 35 samples were not complying with the standard value given by law 48/1982 for ambient water quality (10 mgO2/l). Biochemical oxygen Demand (BOD5) which is a measure for biodegradable organic compounds showed a random distribution but did not exceed the standard value (6 mgO2/l) given by the law. The relationship between COD/BOD values indicates the presence of nonbiodegradable organic compounds, from industrial sources. An increase in TDS from 171 mg/l at Aswan to 240 mg/l at the Delta Barrage has been recorded. But this is within the permissible limit given by the law.

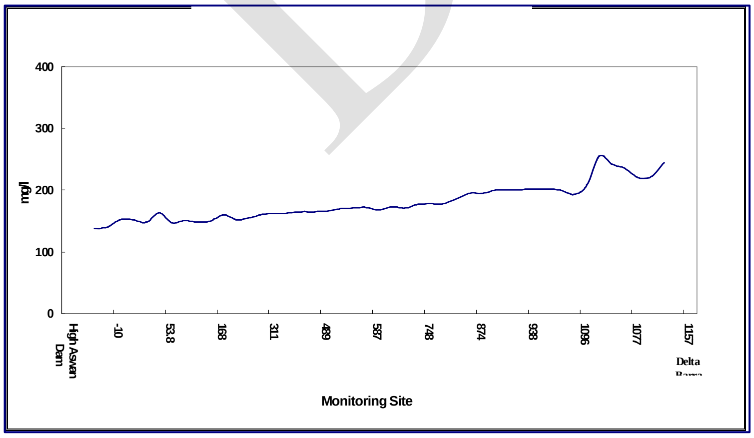



Fig. 19: TDS for the River Nile as of February 2000

***Biological Contamination**:* Law 48/1982 did not specify a standard for fecal coliform (FC) counts for the ambient water quality of the Nile River. Therefore, the value given by the WHO (1989) as a guideline for use of water for unrestricted irrigation ($10^3$/MPN 100ml) has been taken as a guide for the evaluation of the water quality in this report.

The results of the microbiological examination indicated a great variation in the spatial distribution of the fecal coliforms counts. Great exceedances have been found around the catchments areas of Kom Ombo, El-Berba, Main Ekleet and Fatera drains. FC counts in the water samples taken from the specific bank side, where the drain water is pumped, are even higher. This proves the presence of untreated human wastes in these drains.

### 5.4.3.10 The Damietta branch

Major sources of pollution to Damietta branch are Talkha fertilizers factory, High Serw Drain and high Serw Power station.

Assessment of the results of the monitoring trip, which was carried out during February 2001, indicates the following:

- Dissolved oxygen concentration ranged from 7.8 mgO2/l at its southern part to 6.2 mgO2/l, at the northern part.
- Nutrients concentrations (nitrogen & phosphorus) were within the permissible limits.
- The chemical oxygen demand exceeded the standard set by law 48/1982.
- BOD values comply with the consent standard.
- TDS increased from 240 mg/l up to 372 mgO2/l, but the values are still within the permissible limits are not significant in terms of any type of possible water use.
- FC counts exceeded the WHO Guidelines in almost all sampling sites. This is an indication of the discharge of human wastes in Damietta branch.

Table 41: Effluent (m3/day) discharged to agriculture drains in Delta

| Drain | Domestic point Sources $m^3$/day | Industrial Point Sources $m^3$/day | Domestic Diffuse source $m^3$/day | Agricultural Diffuse source $m^3$/day | Total $m^3$/day |
|---|---|---|---|---|---|
| Bahr El-Baqar | 184000.0 | 64268.0 | 122795.0 | 4521678.0 | 6548741.0 |
| Bahr Hados | 80000.0 | 6135.0 | 207754.0 | 4836000.0 | 5129889.0 |
| Faraskour | 2490.0 | 0.0 | 13272.0 | 186758.0 | 202520.0 |
| El-Serw El-Asfal | 7710.0 | 0.0 | 18769.0 | 508515.0 | 534994.0 |
| El-Gharbia Main | 156500.0 | 44460.0 | 293315.0 | 3927556.0 | 4421831.0 |
| Tala | 179.0 | 300.0 | 45076.0 | 1087148.0 | 1134318.0 |
| Sabal | 79000.0 | 0.0 | 39925.0 | 1196384.0 | 1315309.0 |
| No. 8 | 0.0 | 0.0 | 42428.0 | 469848.0 | 512276.0 |
| Bahr Nashart | 22000.0 | 13968.0 | 108915.0 | 968859.0 | 1113742.0 |
| No. 7 | 12500.0 | 0.0 | 39778.0 | 390056.0 | 442334.0 |
| No. 1 | 39350.0 | 20960.0 | 78329.0 | 1204654.0 | 1343293.0 |
| No. 9 | 0.0 | 0.0 | 88029.0 | 595644.0 | 683673.0 |
| Zaghloul | 0.0 | 0.0 | 1838.0 | 122890.0 | 124728.0 |
| Edko | 20000.0 | 7470.0 | 57346.0 | 4232034.0 | 4316850.0 |
| Borg Rashid | 0.0 | 0.0 | 0.0 | 311246.0 | 311246.0 |
| El-Umoum | 25000.0 | 0.0 | 81890.0 | 5163208.9 | 5270098.9 |
| Abu-Keer | 0.0 | 22897.0 | 15803.0 | 621592.2 | 660292.2 |
| El-Batts | 22396.0 | 0.0 | 26213.0 | 1468340.8 | 1516949.8 |
| El-Wadi | 3000.0 | 0.0 | 13272.0 | 1600340.6 | 1616612.6 |
| Total ($m^3$/day) | 2311740.0 | 180458.0 | 1294747.0 | 33412752.5 | 37199697.5 |
| Total Billion $m^3$/year | 0.84 | 0.066 | 0.47 | 12.2 | 13.6 |
| % Ratio | 6.2% | 0.5% | 3.5% | 89.7% | |



***Rosetta Branch***

High concentrations of organic compounds, nutrients and, oil and grease were recorded. Major sources of pollution are Rahawy drain (which receives part of Greater Cairo wastewater), Sabal drain, El- Tahrrer drain, Zawiet El-Bahr drain and Tala drain. At Kafr El-Zayat, Rosetta branch receives wastewater from Maleya and Salt and Soda companies.
Dissolved oxygen concentrations, as indicated by the results of the February 2001 monitoring trip ranged from 5.1 mgO2/l at the southern part to 6.3 mgO2/l at the northern part of the branch.

Nutrient concentrations are within the permissible limits. COD and BOD values exceeded the standards, but were similar to those recorded for Damietta branch.

TDS ranged from 240 at Delta barrage up to 415 mg/l at the end of the branch. With regard to FC, high counts were detected at Kafr El-Zayat, after which the water complied with the WHO Guidelines (1989) for unrestricted irrigation.

### 5.5 Water-Borne Diseases

Throughout history, epidemics related to water- borne or water-related pathogens have plagued Egypt. Some of these events are briefly recounted (Helwa, 1995) here as follows:

- The 1973 typhoid epidemics was localized in a small village in Damietta Province, where about 400 students and villagers fell ill.
- In the summer of 1983, infective diarrhea started in a small village in Giza Province and later spread to other areas. The causative organisms were isolated in drinking water network, which was contaminated by an overflow of sewage caused by broken pipe connection.
- The 1986 typhoid epidemic affected the old section of Suez City. It was the result of heavy contamination of the old water treatment plant intake by untreated human wastes.

The Ministry of Health monitors routinely for pathogenic bacteria, viruses, and parasites in natural water around Egypt. Results of these surveys indicate that the following pathogens have been found in Egyptian waters:

- ***Salmonella***: Have been detected in Alexandria sewage discharged into Mariut Lake, El-Mahmoudia canal and Alexandria beach.
- ***Shigella***: The causative agents of bacillary dysentery were isolated from Mariut Lake. E.histlita and E.coli were detected also in tap water in Abbis II village even though water is treated and chlorinated.
- ***Vibrio Cholera***: As a preventive measure, local health authorities in Egypt collect 110 water samples daily from the Nile and main canals, at the intake point of water treatment plants, and from drains and sewage discharges. The samples have been analyzed for *Vibrio cholera*, with results so far negative.
- ***Parasites***: A clear decline in the presence of infective stage of human with Schistosomiasis (Cercaria). The results indicated a decreasing infected snails (intermediate host) population. Infected canals are by now treated with molluscicide.
- ***Hepatitis A virus***: No figures are available in Egypt
- **Hepatitis E virus**: Have been detected among children, especially in the rural areas.
- ***Viral gastroenteritis***: Gastroenteritis and diarrheal diseases are the most common diseases transmitted by water. These viruses are responsible for 40% among children's under five years of age in Egypt. These diseases are spread by fecal contamination and transmitted to humans via contaminated water supply and food.
- ***Poliomyelitis virus***: These viruses have been detected in sewage in Egypt. It is the only water-borne disease, which has a potent vaccine giving testing immunity to vaccinated children. For this reason, the disease is now being eradicated in Egypt.

Factors responsible for contamination of Egyptian Waters**:**

- Eighty percent of the urban population is reported to have acceptable sanitation, including toilet facilities (55% in developing countries). Seventy–seven percent of the urban population is connected to public sewers.
- In rural areas only 5% of the population is connected to sewers and only about 25% is considered as having some sanitary facilities (15% in developing countries) (Egypt Environment Action Plan).
- About 20% percent of the total population (5% urban and 25% rural) lacks safe public drinking water supplies and rely instead on potentially contaminated, untreated surface water or hand pumps which tap often contaminated shallow groundwater.
- Not all the existing sewage treatment facilities are providing complete secondary treatment of wastewater, and the effluents discharged are either only partially treated or left untreated, especially in the rural areas of Egypt. In addition, in most cases many industries combine their wastes with sewage, discharging them into fresh waterways.

- The contaminated discharge of contaminated agricultural drain waters into fresh waterways constitutes a health hazard due to fecal contamination and the presence of pathogenic organisms.

It is worth mentioning however, that the contamination of natural water results in increased water purification costs and rates. Currently, there are a total of 63 drinking water treatment plants drawing from surface waters, 13 from the Nile and 50 from canals. In 13 of the 26 provinces, drinking water comes from unsafe sources, water samples collected from these provinces showed a high percentage of samples not complying with the bacteriological standards. This was more evident in northern delta, in Damietta, Ismailia, Port Said, Matrouh and Giza.

There are 308 compact water treatment units located on secondary and tertiary canals receiving drains water, 50% of which are located in Northern Delta, namely Dakahilya, Behera, Kafr Al-sheikh and Damietta. Due to poor operation of these units, frequency power failure and contaminated intake, people are consuming water of questionable bacteriological quality. Consequently, the potential for the spread of water-borne and oral diseases is high.

**5.6 Unsuitable Agricultural Practices**

Agricultural practices have had the greatest impact on soil degradation. In recent decades, however, human management of agro-ecosystems has been steadily intensified, through irrigation and drainage, heavy inputs of energy and chemicals, and improved crop varieties led to some general growth in agricultural production, this process has made agro-ecosystems more and more artificial and often unstable and prone to rapid degradation for the following reasons:

- **Irrigation:** Limited water resources required for matching agricultural expansion and the inappropriate utilization of available resources is an obstacle for horizontal expansion. The use of traditional efficient irrigation techniques and the inadequacy of drainage systems have led to the increase in water logging and salinization. Salinity is a potential limiting factor that stifles land productivity in Egypt. Over-exploitation of water for irrigation has led to the depletion of groundwater resources, which has resulted in excessive intrusion of salt water from sea into ground water aquifers.
- **Fertilizers:** Technological advanced cultivation practices, together with the availability of high yield varieties have led to improved crop yields in Egypt over the past two decades. The increased application of chemical fertilizers to supply nutrients is another unsustainable practice in agricultural production. The consumption of the chemical fertilizers in the last years is about one ton per feddan of the cultivated area. The expansion in consumption of fertilizers has been encouraged by the fact that their market is free, and this led to excessive and inefficient application, with consequent economic losses and increased environmental damage.
- **Pesticides:** Pesticides use in Egypt is extremely difficult to assess, simply because there is no possible supervision on small growers and their use of these chemicals. Pests do not only affect the quantitative yield crops both pre-harvest and post-harvest infestations also affect food and feed quality.
- **Soil Erosion**: Further constraints include physical ones, like wind erosion, which affects vast areas on the fringe of desert where the topsoil is sandy and thin. It is one of the serious problems because the fertility depletion through decline in soil organic matter and reduction in nutrient reserves by crop removal, leaching and acidification. Furthermore, the shores of the Delta are being eroded. After the construction of Aswan High Dam, the River Nile is not able to bring sediments to the shores of the Delta. That region is below sea level and is prawn to be submerged with rising sea levels due, in part, to global warming.

5.7 Soil Degradation and Contamination

The term ‘soil degradation’ refers to weakening the current and future capability of soil to produce agricultural products. There are various forms of soil degradation:

- Displacement of soil material by water and wind, which is significant in Egypt.
- Chemical degradation of soil from loss of nutrients or organic matter, salinization, and pollution.
- Physical degradation of soil where the physical process that caused soil degradation is compaction, sealing and crusting, water logging, and subsidence of organic soils.

The use of traditional efficient irrigation techniques and the inadequacy of drainage systems have led to the increase in water logging and salinization. Salinity is a potential limiting factor that stifles land productivity in Egypt. Over-exploitation of water for irrigation has led to the depletion of groundwater resources, which has resulted in excessive intrusion of salt water from sea into ground water aquifers.

According to published research, vehicle emissions affect the soil of the agricultural land around traffic roads. A strip of at least 40 m parallel to the Cairo-Alexandria Agricultural Road receives air pollutants, mainly lead, carbon monoxide, nitrogen oxides and sulfur dioxide. These pollutants fall on the plants as well as passing directly into the soil.

Pollutants carried by irrigation water are also a major source of soil pollution. An estimated 50 percent loss of productivity of agricultural land was recorded at Helwan and Shoubrah El-Kheima. Severe damage to plants has been reported in areas close to the industry in Kafr El-Zayat, Edfu, Abu Za'abal and others. Toxic heavy metals accumulate in the tissues of vegetation grown adjacent to sources of air pollution, such as lead smelters, and near traffic roads.

### 5.8 Threats to the Biodiversity

Egypt's biodiversity has faced threats from various sources. These include intensive agriculture systems, which entail the widespread use of agricultural chemicals in the form of fertilizers and pesticides. Another source of threat is the effects of industrialization. Industrialization programs have accelerated enormously in the second half of the 20th century, and have contributed to the rapid deterioration of the environment. Moreover, excessive hunting of animals and destruction of plant life have endangered the existence of several species of resident and migratory birds, as well as a number of hoofed animals (e.g. gazelles and antelopes).

Accordingly, Egypt is exerting tremendous effort to combat the threats to biodiversity through the conservation of wildlife, natural resources and natural habitat. This is clearly manifested in the declaration of 21 protected areas by prime ministerial decrees in accordance with Law 102/1983, covering about 8% of the total national surface, with plans to have this extended further to 17% by 2017.

### 5.9 Desertification

The desertification of irrigated agricultural lands in Egypt is the result of various practices. One such practice is that of urban development, and building on fertile agricultural lands. In addition, despoliation of agricultural land through the erosion of the surface layer of the soil has left the agriculture land infertile and rendered it unsuitable for cultivation. Likewise, the pollution of soil from wastewater, or from the use of pesticides and chemical fertilizers, and the salinization of agricultural soil are factors contributing to desertification.

## 6. IMPACTS OF POSSIBLE MAJOR DEVELOPMENT OPPORTUNITIES, PROGRAMMES AND PROJECTS ON EASTERN NILE

### 6.1 The Likely Impacts of Major Developments in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

#### 6.1.1 Upper Part of the Sub Basins (Ethiopia)

As Abbay sub basin is endowed with rich water resources, it is one of the options of development in the basin. Among these, irrigation and hydropower development are that got attention. Both Hydropower and irrigation projects will create a range of direct and indirect impacts including the following:

- Disruption of settlement areas and loss of agricultural lands;
- Excessive watershed erosion;
- Upstream deterioration in water quality;
- Downstream flow variation;Environmental and social enhancement (New reservoir fishing industries, draw-down agricultural activates, downstream community water supply, forester and wildlife reserves and rural electrification);
- Inundation losses of primary forests;

- Infrastructure loss,
- Impediments to movement of wildlife, livestock and people;
- Changes in routes of transmission lines;

If the agricultural production is intensified by irrigation, this will create greater use of agro-chemicals and machineries and increase health problems in the basin.

The table below shows the likely and possible impacts of major developments on the Baro-Akobo sub basin of the Ethiopia in Ethiopia (see next page).

Regarding the impacts of major developments on the Tekeze sub basin, the following can be mentioned.

**6.1.1.1 Dams and Reservoirs: -** Screening the preliminary environmental impact of dams has covered the dam site, its reservoir plus a five-kilometre radius “buffer zone” representing the area where malaria infection is most pronounced. The wider catchment area of the reservoir was screened for its erosion potential. Potential negative effects of the dams are related mainly to water borne and transmittable diseases, and changing water regimes. Interaction with surrounding catchments is dominated by soil erosion and siltation of the reservoir (s).

**Micro-dams and prevalence of parasitic infections**: In a survey involving 2,271 people of 410 households around 41 micro-dams, malaria, schistosomiasis and other geohelminthic infections were found to be prevalent with prevalence rates of 1.2%, 7.2%, 8.9%, 2.4%, 2.3% for malaria, schistosomiasis, hookworm, trichuriasis and ascariasis respectively. Prevalence rates reached as high as 20% for trichuriasis and 78% for hookworm around some micro-dams.

Table 42 Possible positive and negative impacts of the proposed projects on Baro-Akobo sub basin

| Project | Positive impact | Negative Impact |
|---|---|---|
| Soil Conservation | | Water Quality, Production losses, soil losses and Gulling |
| Small-holder Agriculture | Better land husbandry, Reducing Soil Degradation, Increase Farm Productivity | Misuse of Agrochemicals, Coffee production |
| Forestry | Habitat for wild life, Protect Soil Erosion, Betterment of Hydrological conditions, betterment of infrastructures, and betterment of human health. | Need of Development of Roads, Increase of wildlife population etc |
| Wildlife | Developing Economy, | No foreseeable negative Impact |
| Tourism | Employment and Income, Expanding of Ethiopians natural Heritage | Polluting Lakes, Removing of Plantation |
| Livestock | Financial benefits, land and vegetation management, reducing flooding, Reduce agricultural pressure, | Degradation of Vegetation resource, Increased soil erosion, Habitat loss, Pollution and health hazard. |
| Fisheries | Increasing catch, Improve House hold income, Human nutrition Improve | Overexploitation, pollution from oil and fuel spill, use of explosive and poison |
| Apiculture | Increase income | Fire risk |
| Hydropower | | |

*Source: Ministry of Water Resources (Ethiopia)*

**6.1.1.2 Irrigation Projects:** The key environmental issues for irrigation projects include the land allocation conflicts, population resettlement, habitat destruction, erosion and changes in water table, water quality, malaria, and other water borne diseases. The majority of these potential negative impacts can be mitigated through best management practices and good project design.

The chemical inputs that are used in in the Ethiopia (Ethiopia) to increase agricultural production are fertilizers, pesticides and herbicides.

**Chemical Fertilizers**: The use of chemical fertilizers in Ethiopia commenced in the late 1960s along with the commencement of integrated agricultural programmes and projects. Ever since then, chemical fertilizers have been popularised and the expansion of their use was promoted through the Agricultural Extension Program. The chemical fertilizers that are in use in the country are DAP and UREA.

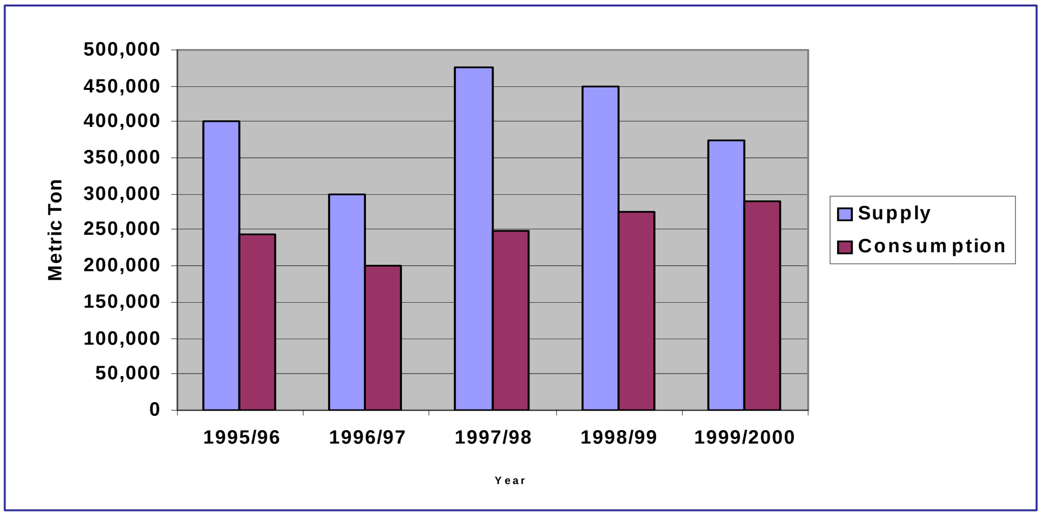



Fig 20: National fertilizer supply and consumption

Information from the Ministry of Agriculture indicates that, in addition to government, private sector firms also import pesticides and herbicides into the country. The amount of pesticides distributed to the regions in 1995/96 was 168, 700 litres while in 1999/ 2000 it was only 138, 510 litres.

The amount of pesticides and herbicides that were imported by the Ministry of Agriculture for application in the agricultural sector is indicated in Table 26. It was not possible to get information regarding the amount imported and distributed by the private importers. As can be surmised from the table, 927.7 tons of chemicals were imported into the country in 1995/96 while in 1999/2000; the amount had increased to 1,081.9 tons. This indicates a 16.6 percent increase over the amount imported in 1995/96.

Table 43: Imported Herbicides and Pesticides (in tons)

| No | Type of Chemical | 1995/96 | 1996/97 | 1997/98 | 1998/99 | 1999/2000 |
|---|---|---|---|---|---|---|
| 1 | Insecticides | 327.21 | 517.657 | 505.019 | 303.34 | 207.64 |
| 2 | Herbicides | 554.00 | 467.45 | 328.15 | 794.22 | 826.76 |
| 3 | Fungicides | 45.79 | 16.06 | 7.89 | 117.30 | 41.61 |
| 4 | Rodenticides | - | - | - | 2.00 | 2.00 |
| 5 | Avicides | - | 5 | 10 | - | - |
| 6 | Plant Growth Regulators | - | - | 20 | - | 4 |
| **Total** | | **926.9** | **1,028.94** | **998.88** | **1230.86** | **1,081.939** |

*Source: Ministry of Agriculture, 2001*

**6.1.1.3 Urbanisation:** Major concern with consequence of urbanization are related first and foremost to urban housing conditions, notably to the level of domestic and municipal sanitary facilities and services and, secondly, to the state of waste disposal, sanitation and safety of working environments. The latter stands for essential characteristics of occupational diseases. In the coming 20-50 years, agro-processing is expected to lead the industrial sector or at least to provide the basis for its development. A survey of major health problems of industries by an expert group of ministry of labour and Social Affairs in the years 1993/94 identified 11 top diseases of manufacturing and large-scale agricultural schemes. These include bronchial asthma, parasitic infections, pneumonia and upper respiratory infections, haemorrhoids, anaemia, tuberculosis, depression, malaria, schistosomiasis, skin diseases and rheumatism in that order of morbidity. For the large-scale agricultural enterprises, the order of importance is malaria, anaemia, gastro-enteritis, malnutrition, pneumonia, tuberculosis, bronchial asthma, skin diseases and accidents. These diseases are related either to poor sanitary facilities in the work environment, to poor waste and sewerage disposal, and to excessive air-borne wastes such as dusts in addition to work related stress.

There are no data describing impacts of chemical hazards such as pesticides in agriculture, agro-industrial development endeavours need to cater for basic requirements of safe working environments, notably acceptable sanitary facilities including a potable water supply, proper waste and sewer disposal, and additional measures to reduce excessive dust, heat, noise, glare, etc. Agricultural development activities also need to include safe pesticide management strategies.

**6.1.1.4 Road Infrastructure:** Road construction usually causes increased erosion leading to increased land degradation and loss of land. Once roads are constructed, they attract increasing amounts of vehicles, causing pollution with their exhaust fumes. In addition, there is a serious risk of traffic accidents; livestock and wildlife movements may be disturbed, etc.

6.1.1.5 Tourism: The management of tourism activities is critical in determining the impact of the industry on its environment. Tourism attraction is typically sensitive natural and man-made environments. In the basin, the sensitive attractions include:

- Simien National Park
- Sheraro Qufta Wildlife Reserve
- Lalibela Rock Hewn Churches
- Gonder Castles
- Monuments at Axum
- Rock Hewn Churches of Tigray

The impact of tourism on the habitats of endangered species such as the Ibex and Simien Fox needs to be carefully controlled. Negative impacts can occur when visitors disturb sensitive habitats during the breeding seasons of endangered species.

Hotels in national parks pollute animal drinking water by releasing untreated sewage into watercourses and vehicle emissions from tourist vehicles pollute the air. Uncontrolled hunting will reduce endangered and rare species below sustainable levels.

Large numbers of tourists visiting churches and monuments can damage wall paintings and carvings by walking on or rubbing against them and create erosion by walking over grassed areas. When high concentration of tourist vehicle and airplane emission is reached, (eg where Vehicles Park or airplanes fly near monuments) acid rain can form which can corrode rock surfaces of historic monuments.

In the basin, however, the volume of tourism has not yet reached a critical level to cause these impacts, even though the thresholds of sustainability could be reached in the foreseeable future.

**6.1.1.5 Industry:** Industrial development in the basin would provide a valuable alternative to livelihoods derived from agriculture. It would have a positive impact in that it would decrease the demand for agricultural land and enable steep slopes to be taken out of cultivation. Where improved agricultural methods are successful, it may be possible to start agro-processing industry, creating added value to local products. The development of tanneries to process hides and skins is likely to be one of the more viable industries.

So far, the emphasis has been on attracting industry. Almost no controls exist on the regulation of industrial process and waste products. The general view among government officials is that industrial activity is of insufficient scale to pose any pollution problems. This may be true in national term but the local level impacts can be severe.

Industrial environmental impacts include:

- Water pollution
- Land contamination
- Air pollution
- Noise
- Visual pollution
- Socio-economic impacts
- Public health impacts

### 6.1.2 Lower Part of the Three Sub Basins (Sudan)

**6.1.2.1 Hydropower Development and Pooling:** Currently, Sudan has 728 megawatts (MW) of electric generation capacity, which includes roughly equal amounts of thermal (mainly oil) and hydropower capacity. The country's main generating facility is the 280-MW Roseires dam located on the Blue Nile river basin, approximately 315 miles southeast of Khartoum. The insufficiency of the country's generation fleet can be attributed mainly to a lack of expansion in the face of rising electricity demand, but has also been exacerbated by the reliance on hydropower generation, which varies depending on rainfall., . In total, it is estimated that only 30% of Sudan's population has access to electricity. In response Sudan's power shortage problems, projects are underway to add both fossil-fuelled and hydropower generating capacity. The largest of these projects are the proposed Merowe and Kajbar hydroelectric facilities in northern Sudan. The 1,250-MW Merowe facility is to be located 250 miles north of Khartoum at the Nile River's fourth cataract. Construction begin in year 2004, with completion scheduled for July 2008.The Kajbar Dam, located at the Nile's second cataract, is currently under construction, and will have a 300-MW capacity (CIA World Fact Book, 2004)

One way to increase access to electricity is through power trade and the co-operative development of hydropower and transmission interconnection investment projects. Significant opportunities for such projects exist in the Eastern Nile countries. There is substantial untapped hydropower potential in Ethiopia and Sudan. The hydropower production and transmission of electricity create diverse and substantial environmental and socio-economic impacts. E.g. flooding from hydroelectric power generation, and clearing of forestlands for transmission lines are major sources of environmental and social controversy and concern around the world. Currently, the electrical industry in Sudan is being subjected to a very strong public pressure in order to minimize its potential negative impacts and improve its social and environmental performance. Special consideration should be given to the assessment of all these potential impacts as well as to the identification of appropriate mitigation measures

**6.1.2.2 Hydropower and climate change:** The increased use of renewable energy is critical to reducing emissions of greenhouse gases in order to limit climatic change. Hydropower is currently the major renewable source contributing to electricity supply, and its future contribution is anticipated to increase significantly. However, global warming and changes in precipitation patterns will alter the timing and magnitude of river flows. This will affect the ability of hydropower stations to harness the resource, and may reduce production, implying lower revenues and poorer returns.

According to Reibsame et al. (1995), Nash and Gleick (1993), and Garr and Fitzharris (1994), the potential changes in annual hydro generation resulting from changes in temperature to +4.7°C (increase of 4.7 degrees) and precipitation of _+22% (increase by 22%) would result in reduction of production equivalent to 21 percent.

**6.1.2.3 Watershed Management:** Watershed of the Blue Nile and its tributaries lie upstream within another nation's boundaries (mainly Ethiopia). Therefore, the causes of the flooding may well be created outside Sudan. Improper land use practices such as deforestation, and overgrazing could lead to soil erosion and desertification, which would increase the runoff from previously normal rainfalls leading to floods and other environmental disasters. Ethiopia (upstream country) may not experience the effects of the flood, while Sudan may have little control over protecting itself from these recurrent floods. This was illustrated by a recent study (Elhassan S, 2005), which indicated that, poor land use practices at the watershed area of the Ethiopian high land has resulted in increased soil erosion and excessive soil deposition in the Blue Nile, reservoir and irrigation canals. The study also indicated that the sedimentation in the lake of the Roseiris Dam has resulted in a decline of the total cultivable area of the Gezira Scheme, in addition to an overall reduction of yield. The study attributed the problem to the water shortage from high sediment deposition resulted from the removal of the vegetation cover and the poor land management in the watershed areas. The results highlighted the need for watershed management, maintenance, conservation of the vegetation cover and the establishment of canal side plantations.

**6.1.2.4 Sustainable management of wetlands and biodiversity conservation:** Sudan is endowed with several wetland areas. Covering an estimated area of 85,000 sq.km .The most important wetlands include**:**

- The Upper Nile swamps: (the Machar Marshes of the upper river Sobat on the Ethiopian-Sudan border), are a very unique wetland habitat characterized by permanent and seasonal swamps each with distinctive plant life. The rain flooded pastures are also an important source of summer grazing for the distinctive Nilotic livestock. The swamp area is also an important fishing ground and supports wildlife.
- Bahr El Ghazal swamp: The swamps of Bahr El Ghazal basin are formed by the torrential rivers, which run out of the slopes of the Nile-Congo Divide. Because of the torrential nature of these rivers, the swamps they form soon dry out when the rains cease. In addition to the Nile's Dams reservoirs such as the Roseires dam reservoir and the wetlands nearby which are a habitat for many birds such as tree duck, white billed cormorant, pink backed pelican, spar wing goose, Egyptian goose and black ring stilt and the Mayas, which are wetland meadows found along the flood plains of the rivers have been formed due to the meandering character of the channel and the nature of flow of its waters. They occupy low-lying basins.
- Given the global significance of Sudan's wetlands, halting wetland degradation would require immediate regional and global attention. Aware of this and of the need for their protection and conservation, Sudan has signed and ratified the Convention on Wetlands of International Importance, especially as Waterfowl Habitats (Ramsar). Moreover, the Management Plan of the Dinder National Park (DNP, 2004) recommended the Improvement of Wetlands Management as an essential component for wildlife and birds conservation.

**Flood Management:** Flood detection and warning systems can be effective in reducing loss of life and property damage. In flash flood locations, the major benefit will be reduction in loss of life. The short lead times limit the amount of active flood proofing that can be accomplished. In slow-rising flood situations, major savings from reductions in flood damage can be accomplished.

Flood detection systems can range from inexpensive networks of volunteer rainfall and stream stage observers and simple rule curves to sophisticated networks of telemetered gauges and computer models. An example of low technology flood detection is an informal system of observers who use the existing infrastructure of telephones to send progressive flood information downstream.

**Disaster Forecasting and Management:** Floods in both forms are highly unpredictable due to the nature of rainfall variability in time and space. The Ministry of Irrigation and Water Resources monitors the Blue Nile, which is the main cause of the floods, once it enters Sudan territory. However, localized flash floods, which occur during the months of August and September, are associated with above normal rainfall and are more difficult to monitor. This highlighted the need for developing a system based on sound scientific research that examines the many complex factors of water management, from weather dynamics to river hydraulics to human demand. The system then becomes a valuable tool for helping policy makers and river basin planners agree on how best to manage the Nile fairly for years to come.

A number of the studies (Elhassan, 2005, ElERahman, 1984) highlighted the need for putting in place an efficient monitoring system for regular monitoring of the sedimentation.

### 6.1.3 Main Nile (Egypt)

*The impacts of development projects (both positive and negative) on Main Nile in Egypt may not be significantly different from those of the middle and upper parts of the Eastern Nile Basin. However, this part has not been covered by the consultant who compiled the initial information on the Main Nile sub-basin of eastern Nile basin in Egypt.*

# 7. INSTITUTIONAL CONSTRAINTS, DATA QUALITY AND GAPS

## 7.1 Data Quality and Information Gaps in Tekeze- Atba-Setit, Baro-Akobo-Sobat-White Nile, and Blue Nile

### 7.1.1 Upper Part of the three Sub Basins (Ethiopia)

The following comments are provided on the data and information collected on the Environment Theme.

The environmental policy of Ethiopia seems to be relatively older in view of the structural and institutional changes that have taken place since the issuance of the policy. In spite of the constitutional considerations for environmental protection, the strength of legal backing and institutional functionalities within the environmental protection activities seems to be less clear in the documents collected so far. The status of environmental protection endeavours in the regions involving the sub basins has not been adequately described and there is hardly any information on the effectiveness and functionality of the environmental structures probably established according to the Proclamation for the Establishment of Environmental Protection Organs.

The basin master plan studies form the most important and relevant components of the datasets collected and compiled during the consultancy services. The natural resources aspect of the physical environment has been treated well and information collected in those regards are invaluable in respect of the data poverty in the country. In the three Nile sub basins in Ethiopia (Abbay, Baro-Akobo and Tekeze) the studies categorically considered the different Physiography and tried to differentiate the magnitudes of phenomenal processes accordingly.

However, in light of the needs arising from ENTRO, the consultant feels that most of those important data sets and information are relatively older to explain current and short-term realities in the sub-basins. The doubts on the effectiveness of those datasets may worsen if the pressing issues like land degradation, erosion hazards, soil loss, deforestation, flooding, environmental threats, etc. are considered. Many of such information are available almost entirely in the highland reclamation studies and documents produced when the Soil Conservation Research Projects were prepared. The durations of those information and accompanying data date back to the mid 1980's and early 1990s.

It is expected that high population densities and consequent greater human pressure on natural resources likely characterize the highland parts of the Nile sub basins in Ethiopia, including land. In highland areas of the sub-basins, extensive cultivation and encroachments into areas of natural vegetation may most probably result in further deforestation, severe erosion hazards and continued loss of soils. Thus in such tendencies, available old datasets may hardly enable to measure the magnitudes of different environmental process in the three sub-basins. It might, therefore, be necessary to carryout land use/land cover surveys; soil erosion hazard assessments and land use/land cover change analysis in order to identify areas of severity and environmentally sensitive zones in the sub basins that form the Ethiopia basin.

No study and report in the sub basins adequately disclosed the potentials for aquatic resources, the state of wetlands and wild life habitants in the sub-basins. The absence of information in these areas of concern seems to have limited identification of hot spots in the context of environmental conservation.

In spite of their importance and relevance, some of the datasets made available by the Ministry of Water resources happened to be incomplete particularly for Tekeze sub basin. None of the spatial data provided for the basin contain descriptions at least for important attributes. The GIS and RS section of the Ministry could not provide complete data, as there has been inadequate building of the databases during the Master Plan study of the basin. In lesser degree, the problem of data incompleteness has also been the case for the remaining basins, too. The following datasets have been found incomplete in attribute description:

- Main roads, Lakes, Farming System, Forest Resources and Main rivers (for Abbay sub basin);
- Forest, soil and Roads, Isohyets, soil geomorphology, and Roads data (Baro-Akobo sub basin);

- Thermal zones, Towns, soil, road, land cover, roads and others (Tekeze sub basin).

However, most of the information and data presented here in this document are based on the study and reports of "Tekeze sub basin Integrated Development Master Plan Project", which aims at combining approaches of river basin planning and integrated regional development plans. River basin planning emphasizes on water resource development, while integrated regional planning deals with multi sectoral development in a spatial planning framework. On the other hand, since all data refer back to the situations in 1994-1996, up-to-date data and information may be necessary for better explanation of current realities of the basin in consideration.

ENTRO, therefore, would be required to remind the GIS and RS section of the Ministry to provide complete datasets of the basins, as the effort of the consultant could not bring about any result from the section.

Despite their common sources, the spatial data from the Ministry of Water Resources seldom provide spatial consistencies. The boundaries of the three basins do not match and similar thematic layers happen to show differences across respective boundaries. Worth mentioning in this connection is the attribute inconsistencies observed in the classifications of land cover/land use and related Physiographic variables. Such inconsistencies may pose some level of technical problems upon integrating the sub basins into one dataset, either across the countries or within Ethiopia itself.

Differences in sources, modelling and generation techniques may also cause limited technical problems also in further processing of some datasets. Some data are software specific and need relevant software for conversion. The naming conventions for some files have been found vague in terms of their thematic issues; the duration of acquisition, method of generation and sources of the base data are not known at all. Therefore, there is a need to use skilled GIS experts for resolving related technical problems.

### 7.1.2 Institutional Constraints and Gaps in the Lower Part of the Three Sub Basins (Sudan)

Management of natural resources faces a set of problems, leading individually or collectively to their unbalanced exploitation and y sustainability. These problems could be attributed to shortcomings related to institutions, including policies, human and institutional capacities, finance, knowledge and information, etc.

#### 7.1.2.1 Policy Failures and Inadequate Institutional Capacity

In spite of the issuance by the government of a number of decrees and legislation that could have largely contributes to sustainable management of natural resources, but still many of the post-Rio environment-related policies remain unimplemented. This is attributed largely to lack of strong implementation or/and enforcement mechanisms for government policies and legislation. For example, from the National Biodiversity Strategy and Action Plan Towards National Implementation Strategy for Climate Change as well as the Sudan's National Action Plan to Combat Desertification (SNAP), none of them has been implemented so far. Moreover, there is also no clearly articulated and multi-sectoral action plan for the implementation of the strategy.

#### 7.1.2.2 Lack of Sufficient Budget

Government institutions remain deprived of the necessary budgetary resources that would enable them provide basic services or perform expected duties and responsibilities. Most of environment-related activities are funded by external donors and NGOs. This reflects the low priority and lack of real political commitment by the government. Years of diplomatic isolation and economic sanctions have deprived Sudan of the technology, trade opportunities and investment that globalization has offered.

#### 7.1.2.3 Insufficient Technical Capacities

Successive wave of brain drain, first to the oil rich countries and lately to North America and Europe for fear of political oppression or for seeking better economic opportunities has largely contributed to depriving the country of well-trained human resource base and skilled personnel. Moreover, there is shortage in institutional capacities (equipment, hardware, software etc)

#### 7.1.2.4 Gaps in Environmental Knowledge Base

Many studies and surveys conducted indicated the gap in information regarding status of environment and natural resources in Sudan. For example, the National Forest Inventory conducted by the Forests National Corporation (FNC) and FAO in 1995 did not include the Southern Sudan because of the instability and civil conflicts.

Other gaps identified during the preparation of Climate Change and biodiversity assessment include the following:

- Lack of an updated information on the forests, wildlife taxonomy and vegetation cover due to irregularity of surveys and lack of systematic monitoring.
- Inaccessibility to historical database due to poor documentation and record keeping;
- Incomplete analysis and presentation of data acquired by means of ground surveys and remote sensing to give a usable output, e.g. Forest Inventory and Afri-cover, 2000;
- Poor coordination between relevant institution and lack of a protocol governing the exchange of information between different government institutions leading to constrained accessibility and utility;
- Continuous political transformation with subsequent changes in the government institutions, policy makers and planners;
- Quick turnover of skilled personnel in search of better economic conditions and secure welfare; and
- Limited opportunities for participation of Sudanese cadre in international and regional issues leading to limited interaction and flow of information from the outside world, because of Sudan's years of diplomatic isolation and economic sanction.

### 7.1. 3 Data Quality and Gaps in Main Nile Basin (Egypt)

Although twenty-five agencies under seven ministries are involved in water quality monitoring program, there are many gaps that can be indicated as follows:

- All monitoring programs are focused only on the conventional parameters and do not cover the sediment and fish samples. Moreover, very limited data is available about the micro-pollutants (pesticides, heavy metals and hydrocarbons);
- There is a high incidence of water-borne diseases in Egypt, especially in Delta region. At the same time, little attention is paid to pathogenic organisms and parasites in water in the current monitoring programs;
- The essential components for effective environmental monitoring are consistency and continuity. If the database or collection system from one source is inconsistent with the base or system used by another source of data, conclusions cannot (or should not) be made based on comparison of the two data sets. In Egypt, there are many governmental and academic bodies collecting data but it is rare to find full comparability between any two sources;
- Furthermore, environmental data need consistency and continuity over time because it is generally all about changes, deterioration or improvement of interest. Many Egyptian data sets have begun as part of a development project supported by donor funds. Unfortunately, many lapses occurred once the foreign-assisted project is finished. For decision making purposes, monitoring the state of the environment over time needs to be supplemented with information concerning violations of the laws. Data concerning violations are not available because of lack of enforcement of existing laws;
- There is a lack of inter-ministerial cooperation and data sharing. Many available reports related to water quality issues relied on old water quality data, which minimize the benefit of these studies; and

  Another important concern is the reliability and validity of the data. In view of the lack of uniformity among the various measurement programs, available data exhibit both random and systematic errors.

## 7.2 Recommendation

Key considerations identified include the following:

- Issues of opportunities and constraints related to sustainable management of natural resources need to be examined in a holistic and balanced manner within the overall context of environment and development, taking into consideration the multiple functions of the resources, including traditional uses, and the likely economic and social stresses and conflicts that could result if the development plans/projects couldn't consider the likely negative impacts on different stakeholders, side by side the potential positive impact created by the development project;
- In order for a multi-purpose development project to achieve its set objective in a sustainable manner it should be based on environmentally sound national guidelines that are based on the national development policies and strategies. In the formulation of such guidelines, account should be taken, as appropriate and if applicable, of relevant internationally agreed methodologies and criteria;
- The decisions on multi-purpose development project should consider the range of benefit and impacts (economic and non-economic) to the society as well as of the environmental costs and benefits. The set of factors, which need to receive explicit consideration, should be expanded to include -among others-: potential impacts of climate change, loss of biological diversity, wildlife habitats, and ecological health;
- Special consideration should be given to important ecosystems in the Eastern Nile e.g. Riverine Forest, which has a vital role in maintaining the ecological processes and balance at the local, national, regional and global levels through, inter alia, their role in protecting fragile ecosystems, watersheds and freshwater resources and as rich storehouses of biodiversity and biological resources and sources of genetic material, as well as their role in carbon sequestration;
- The need for the early detection of any environmental changes resulting from the development project requires that an efficient monitoring system supported by periodic inventories be put in place. This is also important for the provision of timely, reliable and accurate information of change and the spotting of unforeseeable environmental impacts, essential for taking immediate actions and mitigation measures;
- ENTRO should promote and provide opportunities for the broader participation of different stakeholders, including local communities, labour, non-governmental organizations and individuals, and women, in the development, and implementation of the multi-purpose project; and
- In spite of information gaps mentioned earlier, it is hoped that this assessment would succeeded in making important environmental aspects be well understood. Because this would ensure the development of environmentally sensitive activities that care for biodiversity conservation, eco-system integrity as well as the economic sustainability i.e. making the development strategy more environmentally safe, sound and sustainable.

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## Annex One: Statistical Data Generated from Spatial Analysis:

a) Area of Sub basins of the East Nile;
b) Elevation classes in the sub basins of the East Nile;
c) Slope gradients in the sub basins of the East Nile;
d) Land cover distribution in the sub basins of East Nile;
e) Rainfall distribution in the sub basins of East Nile;
f) Mean annual temperature in the sub basins of East Nile;
g) Major soil types in the sub basins of East Nile;
h) Soil Erosion hazards in the sub basins of East Nile.

**a) Area of Sub basins of the East Nile**

| Sub-basin | Area (square kilometer) | Percent |
|---|---|---|
| Baro-Akobo-sobat and white Nile | 469,620 | 26.3 |
| Main Nile | 778,660 | 43.6 |
| Blue Nile | 307,947 | 17.2 |
| Tekeze-Atbara-Setit | 231,397 | 12.9 |
| Total | 1, 787,624 | 100.0 |

**Source: Computations based on Spatial Data Analysis**

**b) Area coverage of elevation classes in the sub basins of the East Nile (Percentage)**

| Basin | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| Low desert (< 250 m) | 0.00 | 14.12 | 0.00 | 0.00 | 3.5 |
| Desert (250-500 m) | 64.32 | 63.88 | 23.78 | 32.18 | 46.0 |
| Lowland (500-1500 m) | 30.12 | 21.90 | 34.51 | 43.46 | 32.5 |
| Mid-altitude (1500 – 2300 m) | 5.09 | 0.00 | 27.31 | 18.57 | 12.7 |
| Highland (2300 -3200 m) | 0.46 | 0.00 | 13.41 | 5.05 | 4.7 |
| Alpine (> 3200 m) | 0.00 | 0.10 | 0.98 | 0.73 | 0.5 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**c) Area coverage of slope gradients in the sub basins of the East Nile (Percentage)**

| Slope categories | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| Flat (< 2.5 %) | 76.83 | 61.92 | 40.83 | 47.63 | 56.8 |
| Moderate (2.5 % -5.00 %) | 16.71 | 35.02 | 32.41 | 26.52 | 27.7 |
| Medium (5.00 - 8.00 %) | 2.78 | 2.09 | 8.83 | 9.18 | 5.7 |
| Gentle (8.00 - 15.00%) | 2.63 | 0.88 | 10.55 | 10.68 | 6.2 |
| Steep (15.00 - 35.00 %) | 1.01 | 0.10 | 7.05 | 5.72 | 3.5 |
| Very steep (> 35.00 %) | 0.05 | 0.00 | 0.33 | 0.27 | 0.2 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**d) Land cover distribution in the sub basins of East Nile (Percentage)**

| Land cover categories | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| Closed evergreen lowland forest | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| Montane evergreen forest (> 100 m) | 4.65 | 0.00 | 1.02 | 0.00 | 1.4 |
| Mosaic forest/Croplands | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| Mosaic forest/Savanna | 0.38 | 0.00 | 0.77 | 0.41 | 0.4 |
| Closed deciduous forest (Miombo) | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| Deciduous woodland | 10.70 | 0.00 | 30.65 | 8.33 | 12.4 |
| Deciduous shrubland with sparse trees | 12.24 | 0.00 | 13.90 | 6.39 | 8.1 |
| Closed grassland | 3.17 | 0.03 | 1.33 | 0.70 | 1.3 |
| Open grassland with sparse shrubs | 9.65 | 0.10 | 3.70 | 5.51 | 4.7 |
| Open grassland | 0.36 | 1.50 | 0.00 | 0.09 | 0.5 |
| Sparse grassland | 4.88 | 2.15 | 3.74 | 8.30 | 4.8 |
| Swam bushland and grassland | 13.11 | 0.03 | 10.65 | 20.45 | 11.1 |
| Croplands (> 50 %) | 27.94 | 0.00 | 16.07 | 12.52 | 14.1 |
| Croplands with open woody vegetation | 1.06 | 2.38 | 1.00 | 1.12 | 1.4 |
| Irrigated croplands | 0.00 | 0.08 | 0.00 | 0.00 | 0.0 |
| Tree crops | 6.25 | 92.50 | 5.58 | 36.08 | 35.1 |
| Bare soil | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| Water bodies | 0.29 | 0.97 | 1.31 | 0.07 | 0.7 |
| Cities | 0.05 | 0.17 | 0.08 | 0.01 | 0.1 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**e) Area coverage of mean annual rainfall distribution in the sub basins of East Nile (Percentage)**

| Rainfall categories | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| Arid (< 300 mm) | 7.59 | 98.76 | 4.95 | 38.45 | 37.4 |
| Sub-moist (300 – 600 mm) | 43.50 | 1.24 | 29.96 | 25.99 | 25.2 |
| Moist (600 – 900 mm) | 18.29 | 0 | 13.82 | 14.93 | 11.8 |
| Humid (900 – 1200 mm) | 25.70 | 0 | 30.24 | 19.36 | 18.8 |
| Per-humid (> 1200 mm) | 4.92 | 0 | 21.05 | 1.27 | 6.8 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**f) Area coverage of mean annual temperature in the sub basins of East Nile (Percentage)**

| Temperature categories | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| < 17.5 $^0$C | 0.00 | 0.00 | 0.00 | 5.94 | 1.5 |
| 17.5 – 20.0 $^0$C | 0.00 | 0.00 | 31.93 | 23.39 | 13.8 |
| 20.0 – 22.5 $^0$C | 5.43 | 6.96 | 13.15 | 7.06 | 8.2 |
| 22.5 – 25.0 $^0$C | 25.70 | 16.02 | 15.51 | 14.27 | 17.9 |
| 25.0 – 27.5 $^0$C | 33.73 | 14.72 | 14.72 | 11.05 | 18.6 |
| 27.5 – 30.0 $^0$C | 35.14 | 32.03 | 24.69 | 38.13 | 32.5 |
| > 30.0 $^0$C | 0.00 | 30.28 | 0.00 | 0.16 | 7.6 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**h) Area coverage of soil erosion hazards in the sub basins of East Nile (Percentage)**

| Temperature categories | Baro-Akobo-sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|
| Tolerable (< 20 t/ha/annum) | 14.12 | 84.36 | 9.58 | 28.15 | 34.1 |
| Low risk (20 – 100 t/ha/annum) | 27.32 | 13.72 | 16.14 | 21.04 | 19.6 |
| Medium (100 – 200 t/ha/annum) | 12.87 | 1.39 | 9.81 | 8.89 | 8.2 |
| High risk (> 200 t/ha/annum) | 45.69 | 0.53 | 64.47 | 41.92 | 38.2 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.0 |

**g) Area coverage of major soil types in the sub basins of East Nile (Percentage)**

| No | Major soil types | Baro-Akobo-Sobat and white Nile | Main Nile | Blue Nile | Tekeze-Atbara-Setit | Average |
|---|---|---|---|---|---|---|
| 1 | Alisols | 2.0 | 0.0 | 3.4 | 0.0 | 1.4 |
| 2 | Arenosols | 10.4 | 35.7 | 0.3 | 2.2 | 12.2 |
| 3 | Calcisols | 0.2 | 3.6 | 0.0 | 0.1 | 1.0 |
| 4 | Cambisols | 2.3 | 2.6 | 6.7 | 18.6 | 7.6 |
| 5 | Fluvisols | 5.2 | 13.0 | 1.3 | 6.5 | 6.5 |
| 6 | Gypsisols | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| 7 | Leptosols | 4.8 | 35.0 | 16.0 | 28.8 | 21.2 |
| 8 | Luvisols | 6.6 | 3.3 | 10.0 | 22.1 | 10.5 |
| 9 | Lixisols | 1.3 | 0.0 | 0.0 | 2.1 | 0.9 |
| 10 | Nitosols | 8.5 | 0.0 | 24.7 | 0.0 | 8.3 |
| 11 | Phaeozems | 0.0 | 0.0 | 0.9 | 0.0 | 0.2 |
| 12 | Plinthosols | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13 | Regosols | 0.0 | 5.4 | 0.0 | 2.3 | 1.9 |
| 14 | Solenchacks | 0.2 | 1.0 | 0.0 | 0.0 | 0.3 |
| 15 | Solentzs | 2.4 | 0.0 | 0.0 | 0.0 | 0.6 |
| 16 | Vertisols | 56.1 | 0.5 | 36.6 | 17.3 | 27.6 |
| | Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |