Nile Basin Initiative

Nile Technical Regional Office (ENTRO)
Nile Basin Initiative Trust Fund / IDA

Eastern Nile Watershed Management Project

Cooperative Regional Assessment (CRA) for Watershed Management

TRANSBOUNDARY ANALYSIS
COUNTRY REPORT
EGYPT

September 2006

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CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS vi
EXECUTIVE SUMMARY viii
1. BACKGROUND 1
1.1 Introduction 1
1.2 Primary Objectives of the Watershed Management CRA 2
1.3 The Scope and Elements of Sustainable Watershed Management........3
1.3.1 Watersheds and River Basins 3
1.3.2 Concepts and Approaches to "Watershed Management" 4
1.3.3 Approach Adopted to the Eastern Nile Watershed Management CRA 6
1.4 Scope and Purpose of the Transboundary Analysis Country Report......7
1.5 Overview of Situation and Issues 8
2. NATIONAL SETTING – EGYPT 10
2.1. Role of the agriculture sector:...10
2.2. Agricultural Economic Resources:...10
2.2.1. Water Resources: 11
2.2.2 Potentials of Developing Egypt's Water Resources: 13
2.2.3 Land Resources: 14
2.2.4 Forest Resources 15
2.3 Human Resources:..15
2.4 Institutional Framework...16
2.4.1 Responsibilities of Institutions with Responsibilities for Water Quality 16
2.4.2 Minister of Water Resources and Irrigation (MWRI) 16
2.4.3 Egyptian Environmental Affairs Agency (EEAA) 17
2.4.4 Ministry of Health and Population (MOHP) 17
2.4.5 Ministry of Housing, Utilities and New Communities (MHUNC) 18
2.4.6 Ministry of Agriculture and Land Reclamation (MALR) 18
2.5 Policy Framework 18
2.5.1 Egypt's Agricultural policy up to 2017: 18
2.5.2 Water Policy 19
3. GENERAL CHARACTERISTICS OF LAKE NASSER/NUBIA 20
3.1 Introduction 20
3.2 Physical Setting 21
3.2.1 Relief and Drainage 21
3.2.2 Geology and Landscape 22
3.2.3 Land cover 25
3.2.4 Water Resources 27
3.2.5 Soil Types 28
3.3 Socio-economic Setting 31
3.3.1 Administrative Structure and Population 31
3.3.2 People and Livelihoods 33

3.4 Agriculture and Farming around Lake Nasser 35
3.4.1 Introduction 35
3.4.2 Cultivated Area: 36
3.4.3 Cropping Pattern (Winter 2005/06) for areas of and around Lake Nasser: 38
3.4.4 Crop productivity of Lake Nasser shore Farms: 38
3.5 Livestock Wealth: 39
3.6 Fisheries in Lake Nasser 40
3.7 Natural Vegetation, Environment and Biodiversity................................42
3.7.1 Natural Vegetation 42
3.7.2 Assessment of the Extent, Trends and Impact of Deforestation and Desertification 42
3.7.3 Biodiversity and Natural Flora, Plant Cover and Genetic Resources: 43
3.7.4 Aquatic ecology 44
3.8 Development Potential around Lake Nasser 47
3.8.1 Introduction 47
3.8.2 Historical development of the area of and around Lake Nasser (Aswan Province): 48
3.8.3 Potential Reclaimable Areas in the Lake Nasser Area 49
3.8.2 The Tushka Depression 53
4. PROBLEM-SOLUTION ANALYSIS 56
4.1 Assessment of the Origins, Extent, Trends and Impacts of Upstream Sedimentation in Lake Nasser/Nubia 56
4.1.1 Origins and Rates of Sedimentation 56
4.1.2 Spatial and Volumetric Extent of Sedimentation 58
4.1.3 Future Trends under Present Sedimentation Rates 58
4.1.4 Impacts of Current and Potential Dam Construction in the Eastern Nile Basin 59
4.2 Environmental and Hydrological Impacts of Impoundment of Water in Lake Nasser 62
4.2.1 Reservoir Induced Seismicity 62
4.2.2 Water Losses 63
4.2.3 Water Quality 65
4.2.4 Bio-chemical Cycling 67
4.3 Water-born diseases 71
4.4 Impacts Downstream of the Aswan High Dam 72
4.4.1 From the AHD to the Delta 72
4.4.2 Impacts on the Coast and Mediterranean Sea 73
4.5 Assessment of the Extent, Trends and Impacts of Wind Blown Sand Sedimentation 74
4.5.1 Origins 74
4.5.2 Extent 74
4.5.3 Trends 75
4.6 Low Agricultural and Fisheries Productivity around Lake Nasser 75
4.6.1 Low Agricultural productivity 75
4.6.2 Low Fisheries Productivity in Lake Nasser 76

4.7 Potential Environmental Issues of Large Scale Development and Settlement in and Around Lake Nasser 77
4.7.1 Introduction 77
4.7.2 Agricultural Development around Lake Nasser 77
4.7.3 Agricultural development of the Tushka Project 78
4.7.4 Mining and Quarrying 79
4.7.5 Expansion of Tourism 79
4.7.6 Increased Use of the Lake for Transport 80
4.8 Organizational and Institutional Issues 80
4.8.1 Agricultural and Fisheries Development 80
4.8.2 Forestry Development 81
4.8.3 The Need for Integrated Lake Basin Development Planning and Implementation 81
5. IDENTIFICATION OF WATERSHED MANAGEMENT INTERVENTIONS.....82
5.1 Potential long term scenarios for sedimentation trends in Lake Nasser82
5.2 Opportunities for extraction and use of sediment deposits 82
5.3 Opportunities and potential activities to reduce sedimentation from wind blown sand 83
5.4 Opportunities and potential activities to support sustainable livelihoods and increased income generation 83
5.5 Opportunities and Potential Activities to Avoid Environmental Damage from Economic Development 84
6. LONG TERM CAPACITY AND MONITORING NEEDS 86
6.1 Capacity Needs 86
6.2 Monitoring Needs 86
7. DATA GAPS 87
BIBLIOGRAPHY 88
ANNEX 1. 96
FLORA OF LAKE NASSER 96

LIST OF ACRONYMS AND ABBREVIATIONS

AHD	Aswan High Dam
BCM	Billion Cubic Meters
BOD	Biochemical Oxygen Demand
CAP	Compliance Action Plan
CAPMAS	Central Agency for Public Mobilization and Statistics
CIDA	Canadian International Development Agency
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DRI	Drainage Research Institute (NWRC)
EEAA	Egypt's Environmental Affairs Agency
EEIS	Egypt Environmental Information System (a CIDA project at EEAA)
EHD	Environmental Health Department (MOHP)
EIA	Environmental Impact Assessment
EIMP	Environmental Information and Monitoring Program
EMUs	Environmental Management Units
EOHC	Environmental and Occupational Health Center (MOHP)
ERC	Environmental Research Council
FAO	Food and Agriculture Organization of the United Nations
FC	Fecal Coliforms
GOE	Government of Egypt
GOFI	General Organization for Industrialization
HAD	High Aswan Dam
IIP	Irrigation Improvement Project
IPM	Integrated Pest Control
LCD	Liters per Capita per Day
MALR	Ministry of Agriculture and Land Reclamation
MSEA	Ministry of State for Environmental Affairs
MOHP	Ministry of Health and Population
MHUNC	Ministry of Housing, Utilities and New Communications
MOI	Ministry of Industry
MWRI	Ministry of Water Resources and Irrigation (previously MPWWR)
NAWQAM	National Water Quality and Availability Management (CIDA project)
NEAP	National Environmental Action Plan
NOPWASD	National Organization for Potable Water and Sanitary Drainage (MHUNC)
NRI	Nile Research Institute, NWRC (previously known as: HADSERI)
NWRC	National Water Research Center, MWRI
NWRP	National Water Resources Plan
PPM	Parts Per Million
PRIDE	Project in Development and the Environment (USAID)

RIGW	Research Institute for Groundwater (NWRC)
TDS	Total Dissolved Solids
TSP	Total Suspended Particles
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
VOC	Volatile Organic Compounds
WHO	World Health Organization
WPAU	Water Policy Advisory Unit (MWRI)
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

1. Scope of the report:

The Eastern Nile Basin in Egypt comprises the Nile Basin from the border with Sudan to the Aswan High Dam.

The Transboundary Analysis component comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins, and to opportunities and benefits of cooperation in watershed management. The analysis is being undertaken in five stages:

- National level analysis for the agreed Sub-basins;

This is the subject of this report. This will be followed by

- A Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;
- Consolidation of the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;
- Identification of additional benefits of cooperation in watershed management by identifying potential additional cross-border positive and negative impacts of watershed related interventions;
- Distillation from the system-wide analysis the greatest system-wide opportunities for high impact cooperative watershed management.

This report contains the results of the National level analysis for the Eastern Nile Basin within the catchment area of Lake Nasser/Nubia. The whole lake is considered as one hydrological system and thus includes a part of Sudan as well as the catchment area within Egypt. The Report comprises:

(i) a review of successful experiences of interventions to address watershed interventions (with a specific view of approaches aiming at improved livelihoods);

(ii) stakeholder consultations in selected relevant locations;

(iii) a detailed problem and solution analysis for each watershed for current trends in land degradation;

(iv) policy and institutional issues conducive as well as hindering successful interventions on the national level; and

(v) an outline of long-term capacity building and monitoring needs to evaluate successes/impacts of interventions on the watershed.

2. Understanding of the Biophysical and Socio-economic Aspects of the three Sub-basins:

The Report then provides a detailed description of the biophysical and socio-economic aspects of the Sub-basin. It first provides an overview of the agricultural and forestry sectors and provides some details of production and marketing systems.

3. Summary of the Proximate Problem Analysis:

A key problem is sedimentation in the reservoir. About 95 percent of the suspended sediment is derived from the Abay/Blue Nile and the Tekeze/Atbara as most sediment from the White Nile is filtered in the Sudd. The average sediment load entering the reservoir is about 125million tons[1]. Since 1973 cross-section measurements have been taken at selected points the follow changes in the lake bed. By 1973 about 20 meters of sediment had been deposited near the Second Cataract (345-370kms upstream from the Aswan High Dam). From Km 345 to km 285 the deposits decreased to less than 1 meter forming an inland delta some 85kms long. However, by 2000 the maximum deposits had reached 60 meters near the Second Cataract and deposition of sediment now reached 120kms from the dam. Thus, the inland delta had extended some 165kms in just 27 years and now stretched 250kms.

Predictive analysis of the groundwater situation of Lake Nasser suggests that impedance of silting in the Lake and the gradually decreasing difference between lake stage and near-lake heads are causing a general rise in Lake Nasser surface water level and a decrease in groundwater re-charge rates from the lake with time[2]. The analysis is the result of preliminary groundwater models for the south-western corner of the lake. This joint study is still ongoing.

An additional problem is wind blown sand that is also contributing to the sedimentation on the western side of the reservoir. This is also a problem for the main Nile in Sudan.

[1] Mohamed El Moattassem (2005) "Aswan High Dam: Environmental Side Effects", paper presented at the Eastern Nile Watershed Management CRA Regional Workshop, Barhir Dar, December 5-6th 2005.

[2] Western Michigan University/MoWRI (2006) "Towards a better understanding of the hydrology of lake Nasser, Egypt", Web site: Earth Sciences and Remote Sensing, Western Michigan University, USA.

The dam acts to retain almost 100 percent of the sediment load. One result has been erosion of the river bed below the dam along flat reaches and deposition in the narrow reaches. Bank erosion is also occurring due to the decrease in water level because of increasing bank height, wash from boats, channel meanders and seepage of ground water.

Around the Lake substantial flood retreat agriculture is practiced by migrants from the middle and upper Nile Valley. The current production levels are low from a variety of causes. Among these are

a- Technical Problems:

- Lack of an appropriate soil texture and composition.
- Difficulty of leveling the surface layers; and therefore, slope cultivation is commonly used.
- Fluctuation of Lake water level during growing season.
- Absence of organic matter.
- Lack of macro-and micro-nutrients.
- Shallowness of top soil.
- Presence of soluble or less soluble salts such as calcium carbonates and gypsum.
- Continual change in the surface layer as a result of wind movement.
- The presence of certain harmful elements such as boron and selenium.
- Salinity and alkalinity problems.
- Drainage problems.
- Lack of research/extension.
- Lack of certified seeds.

b- Economic problems:

These include:

- Lack of sufficient investments in infrastructural facilities. This problem was further aggravated by inadequacy of monetary liquidity, prolonged procedures of lending.
- Inability of the official investments to create integrated settled communities in and around the lake to attract new settlers from the Nile Valley and Aswan-which are already overpopulated and parts of their croplands are lost to urban uses.
- Inaccessibility to credit by the new graduates and beneficiaries thus impeding their ability to fully use their lands.
- Marketing accessibility.

There are a number of problems related to the low productivity of fisheries in Lake Nasser. These include:

- Fishermen use illegal fishing methods including nets with mesh smaller than the legal limit.
- Unlicensed boats.
- Smuggling of fish.
- Over-fishing: excessive and indiscriminate fishing occurs in the lake.

The Government of Egypt plans major agricultural, tourism and mining developments and settlement of large numbers of people around the lake and in the Tushka Depression over the next 15 years. A number of potential environmental impacts are identified.

4. Identification of Watershed Management Interventions;

The Report identifies a number of potential interventions. These include the potential for dredging sediment and its use for a number of industrial and agricultural purposes. On-going cost-benefit investigations should reveal the economic potential of these.

The use shelter belts to reduce the amount of wind blown sand into the Lake is discussed and a number of recommendations made.

A number of interventions are proposed to increase agricultural and fisheries production and so increase income and enhance sustainable livelihoods. The Bio-organic Control project has identified a number of natural pest control measures that obviates the need for chemical control.

The urgent need to develop an environmental action plan for the Lake and its environs is proposed to avoid large scale negative impacts in this fragile environment. There is also a need for integrated planning of developments: agriculture, settlement, tourism and mining.

Finally the long term capacity and monitoring needs are outlined.

1. BACKGROUND

1.1 Introduction

The Eastern Nile Basin Watershed Management Cooperative Regional Assessment (CRA) is in support of the Eastern Nile Subsidiary Action Programme (ENSAP). ENSAP, which includes Egypt, Ethiopia and the Sudan, seeks to initiate a regional, integrated, multi-purpose programme through a first set of investments. The umbrella organization for ENSAP is the Nile Basin Initiative (NBI) see figure 1. The NBI has 8 programmes and these cover the whole of the Nile basin.

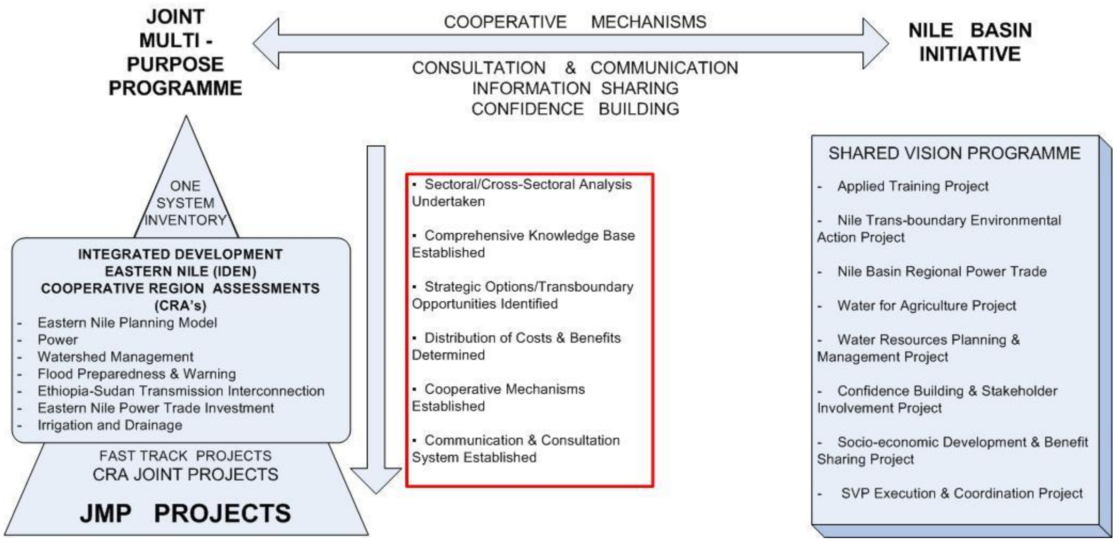
The first project under ENSAP, referred to as The Integrated Development of the Eastern Nile (IDEN), comprises seven components:

- Eastern Nile Planning Model,
- Baro-Akobo Multi-purpose Water Resources Development,
- Flood Preparedness and Early Warning,
- Ethiopia-Sudan Transmission Interconnection,
- Eastern Nile Power Trade Investment,
- Irrigation and Drainage, and
- Watershed Management

The results of the analyses of the sectoral CRA's will be brought together in the design and decisions in a joint multi purpose programme (JMP) of interventions. The general elements of a CRA are (i) institutional strengthening, (ii) a participatory process for building trust and confidence, and (iii) to gain a transboundary understanding the watershed system from a basin wide perspective.

The results of the Watershed Management CRA will provide valuable input to the JMP planning. The CRA will highlight some of the major issues relevant to the JMP, identify transboundary benefits and develop long term cooperative arrangements for monitoring land use change, sediment loads and impacts on livelihoods.

Figure 1. Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme

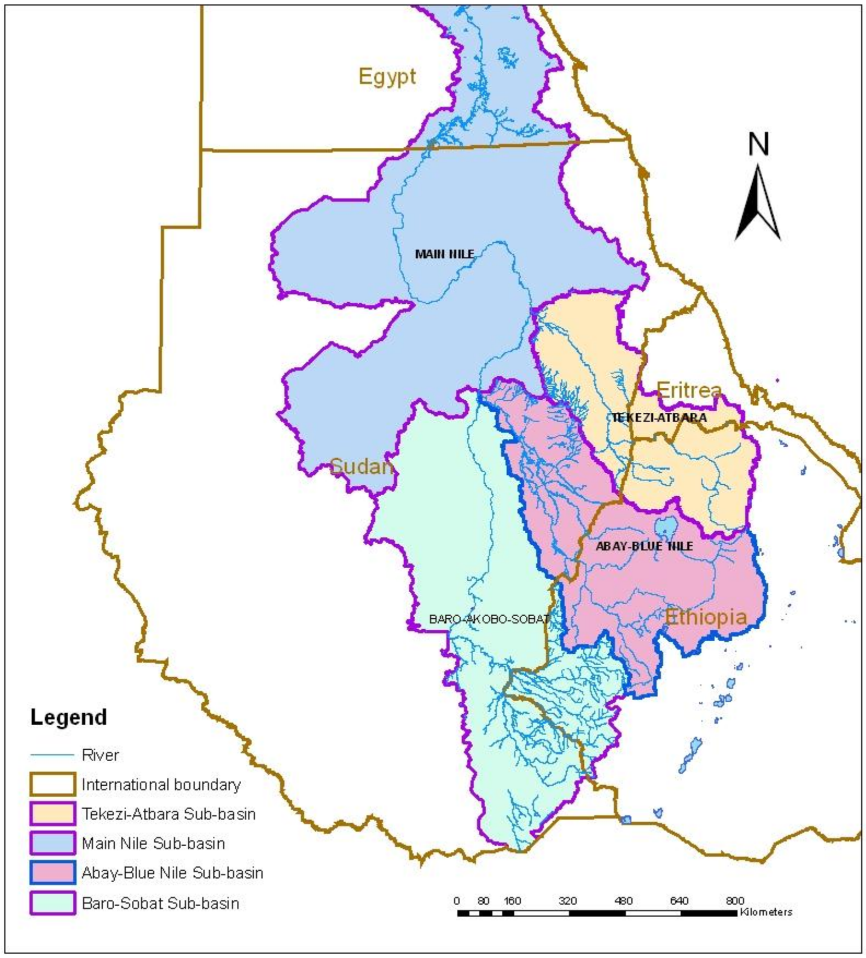


1.2 Primary Objectives of the Watershed Management CRA

The project focuses on four watersheds: the Abay/Blue Nile, Tekezi/Atbara, the Baro-Sobat-White Nile and the main Nile from Khartoum to the Aswan High Dam (Map 1). The primary objects of the Watershed Management CRA are to develop a sustainable framework for catchment management in order to:

- Improve the living conditions of all peoples in the three sub-basins
- Create alternative livelihoods
- Achieve food security
- Alleviate poverty
- Enhance agricultural productivity
- Protect the environment
- Reduce land degradation, sediment transport and siltation.
- Prepare for sustainable development orientated investments.

EASTERN NILE BASIN
LOCATION OF THE SOBAT,
ABAY-BLUE NILE, TEKEZI-ATBARA
AND THE MAIN NILE SUB-BASINS



Map 1. Eastern Nile Basin: with the Tekeze-Atbara, Abay/Blue Nile, Baro-Sobat-White Nile and the Main Nile Sub-basins.

1.3 The Scope and Elements of Sustainable Watershed Management

1.3.1 Watersheds and River Basins

River basins, watersheds and sub watersheds and their hydrological processes operate in systemic way within a nested hierarchy but often in complex spatial and temporal patterns. For example, the linkages (or coupling) between vegetation cover, soil erosion (or soil conservation) and sediment yield at the micro-watershed level and the sediment load and sedimentation downstream at the macro-watershed level often do not have simple linear relationships.

Terminology is generally based on area, although given the potential for extreme variability in other hydrological factors, this is of necessity rather arbitrary. The following classification was used in a recent World Bank assessment of World Bank funded Watershed management projects.

Table 1. Watershed Management Units and Hydrological Characteristics

Management Unit	Typical area (km2)	Example	Degree of coupling
Micro-watershed	0.1 -5km^2	Typical watershed adopted by MERET interventions (Ethiopia)	Very strong
Sub-watershed	5 – 25km^2	An assemblage of micro-watersheds	Strong
Watershed	25 -1,000km^2	Guder	Moderate
Sub-basin	1,000 – 10,000km2	Lake Tana	Weak
Basin	10,000 – 250,000km2	Abay-Blue Nile	Very weak

After World Bank (2005)[3]

In micro and sub-watersheds there is a strong coupling between the catchment area and the channel. Vegetation and land management practices closely control the runoff and the export of water, sediment and dissolved load into the stream channel. There is also a close coupling between groundwater and the river. In medium to large basins coupling between the catchment and the river is weak. The dominant process in basin of this size is transfer of material through the channel network and there is often temporary storage of sediment. Thus, the channel acts as a conveyor belt intermittently moving pulses of sediment during flood events. There is additional sediment from stream bank erosion and drifting sand.

1.3.2 Concepts and Approaches to "Watershed Management"

The term "Watershed Management" or often "Integrated Watershed Management" can be viewed from a number of perspectives. One frequently used perspective in the past was that of water management for water supply and/or flood control. A second commonly adopted perspective in the past was that of land management and could encompass soil conservation, forestry, rangelands and land use planning. More recently, a more or less comprehensive approach has been adopted that includes land and water management but also

[3] World Bank (2005) "Watershed Management in World Bank Operations (1999-2004): Emerging Lessons, Strategic Issues, Recommendations for Practitioners", unpublished WB report.

encompasses socio-economic concerns (poverty reduction, sustainable livelihoods, externalities, increased and sustainable agricultural production), technical, institutional and policy issues and seeks to integrate environmental with socio-economic goals

James (2005) distinguishes between a more narrow "Watershed Development" approach and a number of broader "Watershed Management" approaches. "Watershed Development" includes the narrower water or land perspective with the emphasis on physical development activities related to soil conservation or water resources development.

From the "Land" perspective the term **Sustainable Land Management** (SLM) is frequently used, putting more emphasis on the need of sustainable use and development of land as an economic production factor, with a farm holding is the basic unit, but with watershed principles respected for the sake of resource sustainability.

Integrated Water Resource Management (IWRM) is one such approach that seeks to integrate the various water-using sectors. It emphasizes water resources, while still considering all other functions in the basin, and leaving the responsibility for rural development to those with a mandate of integrated regional development. Although the 2000 Global Water Partnership – Technical Advisory Committee defined ***IWRM** as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of the vital ecosystems*". This definition approaches some of the broader approaches outlined below.

James describes a number of approaches developed under the umbrella of "Watershed Management". These include:

Agro-ecosystems Approach: seeks to maximise multiple objectives of productivity, stability, sustainability and equity. It does not however explicitly consider externalities.

Watershed-based Rural Development Approach: has been adopted in India from the early 1990's and is characterized by the grafting onto a Watershed Management programme a Poverty Reduction programme. This approach has generally focussed on employment generation through soil conservation activities, although a number of such programmes are being transformed using participatory and livelihoods approaches outlined below.

Participatory Approach to Watershed Management: has been pursued in various forms since the 1980's. It seeks to place local stakeholders at the centre of planning and implementation. Rhoades (2005) has outlined a number of conceptual and operational challenges in implementing Participatory Watershed Management although Hinchcliffe et al (2005) provide a number of ways of overcoming these challenges. The "Watershed Plus" approach in India to address stakeholder demands in other sectors such as sanitation, health, education and public infrastructure.

Livelihoods Approach to Watershed Management: was developed by UK DFID in the late 1990's as an analytical approach that could be used for planning, implementing and monitoring a range of development programmes including Watershed Management (Turton, 2000). It has stakeholder participation in planning and implementation at its core and seeks to encourage a more explicit analysis of the ways in which Watershed Management can directly and indirectly affect peoples' livelihoods and enhance positive poverty reducing impacts.

Externalities in Watershed Management: are widespread in watershed due to (i) hydrological linkages upstream and downstream, and in the case of the Eastern Nile Basin, across international boundaries, and (ii) socio-economic linkages across property boundaries and communal lands. "Externality-based frameworks are not common in watershed management, and are only being understood, documented and evaluated relatively recently". (James).

1.3.3 Approach Adopted to the Eastern Nile Watershed Management CRA

> *" In view of the multi-sectoral nature of the problem (land degradation, fuelwood demands, population pressures, illiteracy, lack of alternative sustainable livelihoods, etc.) a comprehensive and integrated approach is required, as traditional watershed management actions, in this case, would treat the symptoms, as opposed to address the root causes which lead to the spiral of degradation and poverty.*
>
> *The preparation of an integrated watershed program in the Eastern Nile region will require a holistic approach and interaction between national level and regional studies through a Cooperative Regional Assessment (CRA)."*

(Terms of reference: Cooperative Regional Assessment in Support of the Eastern Nile Watershed Management Project.)

Clearly, the approach to be adopted in developing a framework for watershed management for the Eastern Nile Basin needs to be very broad in order to address a wide-range of objectives based on stakeholder perspectives across multiple levels and countries. The objectives to be addressed go beyond developing and conserving land, water and vegetation in the four sub-basins in the three countries. They include but are not limited to:

- supporting rural livelihoods by integrating interventions in other "non-watershed" sectors (e.g. health in pond development, training in non-farm employment activities);

- addressing equity concerns in the distribution of costs and benefits of watershed interventions (e.g. positive and negative externalities at various levels);

- identifying opportunities for incremental benefits accruing to cross-border coordinated interventions, including those being developed for the other IDEN CRA's and the Joint Multi-purpose programme (JMP);

- identifying global benefits accruing from national and regional level interventions.

At the same time it will be important to maintain a "Watershed Perspective". This is necessary to avoid a lack of focus on the unique upstream-downstream characteristics of watersheds and river basins. Maintaining such a perspective will avoid the danger of the analysis failing to develop a "system-wide" understanding of the basin-wide issues and thus the identification of transboundary opportunities to improve livelihoods and achieve poverty reduction. Finally, a Watershed perspective will enable the identification of basin-wide synergies from cooperative transboundary interventions.

An essential element of the Watershed Management CRA approach that distinguishes it from many Watershed Management approaches is the "Regional Process": i.e. building capacity, trust and confidence among riparian stakeholders. This will be made operational through a continuous process of regional stakeholder consultation.

1.4 Scope and Purpose of the Transboundary Analysis Country Report

The Transboundary Analysis component comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins, and to opportunities and benefits of cooperation in watershed management. The analysis is to be undertaken in five stages:

- National level analysis for the agreed Sub-basins;

- Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;

- Consolidate the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;

- Identify additional benefits of cooperation in watershed management by identifying potential additional cross-border positive and negative impacts of watershed related interventions;

- Distill from the system-wide analysis the greatest system-wide opportunities for high impact cooperative watershed management.

The analysis at the national level includes:

(vi) a review of successful experiences of interventions to address watershed interventions (with a specific view of approaches aiming at improved livelihoods);

(vii) stakeholder consultations in selected relevant locations;

(viii) a detailed problem and solution analysis for each watershed for current trends in land degradation;

(ix) policy and institutional issues conducive as well as hindering successful interventions on the national level; and

(x) outline long-term capacity building and monitoring needs to evaluate successes/impacts of interventions on the watershed on local livelihoods, agricultural output and sedimentation control.

National reports will be assembled based on the points outlined above.

1.5 Overview of Situation and Issues

The relevant part of the East Nile Basin for this study is the area of and around Lake Nasser/Nubia. The whole Lake is considered as one hydrological system and thus the area of study includes that part of the Lake (Lake Nubia) that is within the Sudan, as well as that part located within Egypt.

The Aswan High Dam (AHD) was completed in 1970 with a storage capacity of some 162 billion m^3 and a hydro-power generating capacity of 2100MW. The dam provides long term storage buffering against periods of low flow (e.g. during 1978-88) providing sufficient water for two crops a year. It also provides flood protection for land downstream.

The key problem is sedimentation in the reservoir. About 95 percent of the suspended sediment is derived from the Blue Nile and the Atbara as most sediment from the White Nile is filtered in the Sudd. The average sediment load entering the reservoir is about 125million tons[4]. Since 1973 cross-section measurements have been taken at selected points the follow changes in the lake bed. By 1973 about 20 meters of sediment had been deposited near the Second Cataract (345-370kms upstream from the Aswan High Dam). From Km 345 to km 285 the deposits decreased to less than 1 meter forming an inland delta some 85kms long. By 2000 the maximum deposits had reached 60 meters near the Second Cataract and deposition of sediment now reached 120kms from the dam. Thus, the inland delta had extended some 165kms in just 27 years and now stretched 250kms.

Predictive analysis of the groundwater situation of Lake Nasser suggests that impedance of silting in the Lake and the gradually decreasing difference between lake stage and near-lake heads are causing a general rise in Lake Nasser surface water level and a decrease in groundwater re-charge rates from the lake with time[5]. The analysis is the result of preliminary groundwater models for the south-western corner of the lake. This joint study is still ongoing.

An additional problem is wind blown sand that is also contributing to the sedimentation on the western side of the reservoir. This is also a problem for the main Nile in Sudan.

The dam acts to retain almost 100 percent of the sediment load. One result has been erosion of the river bed below the dam along flat reaches and deposition in the narrow reaches. Bank erosion is also occurring due to the decrease in water level because of increasing bank height, wash from boats, channel meanders and seepage of ground water.

[4] Mohamed El Moattassem (2005) "Aswan High Dam: Environmental Side Effects", paper presented at the Eastern Nile Watershed Management CRA Regional Workshop, Barhir Dar, December 5-6th 2005.

[5] Western Michigan University/MoWRI (2006) "Towards a better understanding of the hydrology of lake Nasser, Egypt", Web site: Earth Sciences and Remote Sensing, Western Michigan University, USA.

2. NATIONAL SETTING – EGYPT

2.1. Role of the agriculture sector:

The Egyptian economy has traditionally relied heavily on the agriculture sector as a source of growth, both in terms of contribution to GDP as well as a source of employment to a significant part of the Egyptian labour force. It accounts for about 16 percent of both growth domestic product GDP and total exports and about 34 percent of employment. Following the completion of the High Aswan Dam (HAD) in 1968, the agriculture sector, in 1974, accounted for 30% of GDP, 25% of export earnings and 47% of employment. However, this dominance has declined gradually over the years and the share of agriculture in GDP and export was each about 20% in 1990. This share now accounts for 16% in GDP, 20% in export and about 34% employment (World Bank' 2003).

While average growth rates for the sector have been modest during the past decade, more recent indicators point towards progress. For example the production of wheat, maize, rice, sugar, fruits and vegetables have recorded significant increases over the past decade. The cotton sub-sector is beginning to show signs of revival, and horticultural production having increased significantly, the sector will continue to support agro-industrial growth in the country. Development in the agricultural sector is expected to lead the nation's efforts to achieve equitable and balanced growth in the rural economy. Despite the decline in the share of sector's contribution to the national GDP, as shown above, the sector remains crucial for the future of Egypt's economy.

Agriculture in Egypt is entirely dependent on irrigation from the Nile which is the main source of water supply. The Egypt-Sudan Nile Water Agreement of 1959 gives Egypt 55.5km^3, representing more than 95% of the total developed water resources of Egypt. The Nile system has a single input from the AHD and only two outputs, namely, drainage to the sea and evapotranspiration.

2.2. Agricultural Economic Resources:

Land, water and human resources are the major foundations of Egyptian Agriculture. These three resources set the limits to future agricultural growth. Land and water are relatively scarce, and their use is governed by certain technical limitations.

2.2.1. Water Resources:

Egypt's water resource base mainly consists of:

- Egypt's quota from the Nile.
- Underground water.
- Effective rainfall and torrent water.
- Non traditional water resources which include:
  - Intermediate reuse of agricultural drainage water and treated wastewater;
  - Desalinated water.

The total water resources now available to Egypt is estimated at 73.663km3 billion cubic meters per annum including the natural and non-traditional resources (table 1). Table 2.2 shows the distribution of water resources among various sectors. The agricultural sector consumes about 81% of total water available.

(i) Nile Water

The Nile is the major source of water in Egypt. Egypt is almost entirely dependent on irrigation. Consequently, agricultural development is closely linked to the Nile River and its management. The Nile Waters Agreement between Egypt and Sudan in 1959 gave Egypt 55.5 billion cubic meters, almost more than 90% of the country's developed water resources.

Table 2. Available Water (2000) (km3/annum)

Source	Available Quantity	%
River Nile	55.500	76.0%
Renewable Groundwater	2.300	3.1%
Reuse of Agricultural Drainage Water (return flow to rivers)	4.840	6.6%
Reuse of groundwater (Seepage from agriculture)	6.127	8.3%
Treated Wastewater	2.971	4.0%
Desalinated water	0.100	0.1%
Use of fossil groundwater (non-renewable)	0.825	1.1%
Effective Rainfall	1.300	0.7%
Total	**73.963**	**100**

Source: FAO (2005) "Irrigation in Africa: AQUASTAT Survey 2005", Rome.

Table 3. Distribution of Water Use by Sector (km3/annum)

Sector	Consumptive Use	%
Agriculture	59.00	86%
Industrial & Municipal Uses	4.00	6%
Domestic	5.30	8%
Total	**68.3**	**100**

Source: FAO (2005) op. cite

In addition to the 68.3km3 an additional 4.0km3 was used for navigation and hydro-power generation.

A major feature of the strategy for agricultural development in Egypt is to benefit from a variety of improvements in the efficiency of the Nile system in order to increase the productivity per unit of water.

(ii) Underground Water

Egypt has three major reservoirs of underground water they are:

- Valley and Delta Reservoirs.
- The Nubian Sandy aquifer in the Eastern and the Western desert, around the High Dam's lake and in Sinai,
- Calcareous rocky aquifer scattered nationwide.

The Nile basin reservoir is highly efficient in storing water. Approximately 4.0 billion cubic meters, of the total 7.5 billion cubic meters are drawn annually from this reservoir to provide the surrounding towns and villages with potable water.

(iii) Rainfall and Torrents

Egypt has no effective rainfall except in a narrow band along the north coast area where an average of 120-200mm annually is precipitated. The total torrent water is estimated at 1.5 billion cubic meters annually. MWRI builds dams on certain valleys to store torrent waters for future uses and for feeding the underground reservoirs.

(iv) Non-traditional Water Resources:

Approximately 4.5km^3/annum are reused in irrigation. There is a potential for intermediate reuse of about 5km^3 annually, out of 12km^3 being drained into the sea to maintain the salt balance of the Delta soils and the underground water. Treated wastewater reuse is currently estimated at 1.5 km^3 annually.

Desalination projects are planned at the coastal areas to meet the demand of the tourist projects under construction.

2.2.2 Potentials of Developing Egypt's Water Resources:

The per capita share of water is decreasing on annual basis due to the scarcity of fresh water resources for a population growing at 2% annually. Therefore, Egypt has embarked on a number of projects to rationalize water use.

i. Irrigation Improvement Program (IIP) IIP was designed to reduce losses by using modern control structures, lining of the misqas (on-farm aqua-duct), laser leveling, using one pump on the commonly shared misqa and installation of plastic (PVC) pipes.

ii. Develop short duration, high-yielding rice varieties in order to save rice consumptive water use.

iii. Weed control in the water streams to reduce water loss and abate environmental pollution.

iv. LASER Leveling and gated pipe irrigation of sugar cane. Rationalization of water use in the municipalities, industrial projects and infrastructure rehabilitation is expected to considerably increase water resources by 2017 as follows:

Table 4. Projected Increases in Water Supply from various Sources by 2017 (km3)

1- Underground water in the Valley, the Delta and Deserts	6.1 km3/annum
2- Reusable agricultural drainage water	5.0 km3/annum
3- Reusable treated wastewater	1.5 km3/annum
4- One million feddans grown to short duration rice	4.0 km3/annum
5- IIP in old lands	2.0 km3/annum
6- Egypt quote from Jonglei Canal adds	2.0 km3/annum
Total	**20.6 km3/annum**

These additional water resources are set against non-agricultural uses of about

4.0 km^3/annum, as stated below:

Municipal uses	1.5 km^3/annum
Industrial uses	2.5 km^3/annum
Total	**4.0 km^3/annum**

The surplus quantity amounting to 16.6 km^3/annum can be used in horizontal expansion since the present strategy up to 2017 aims at reclaiming 3.4 million feddans to increase the contribution of agriculture to the GDP.

2.2.3 Land Resources:

Egypt has an area of about one million square kilometers or 238 million feddans. According to the 1990's agricultural census, the total cultivated area was estimated at 7.5 million feddans, (Fed. = 4200m2) which consists of 5.5 million feddans of old land and 2.0 million feddans of new land.

Table 5. Reclaimable land in Egypt by regions

Potential land reclamation by Regions	Land categories (1000 Feddan*)						Priority areas (1000 feddans)
	I	II	III	IV	V	Total	
With Nile water							
East Delta	286.5		135.1	43.5	351.6	798.7	**612.0**
West Delta	41.5	171.2	49.1	65.0	358.1	684.9	**264.0**
Central Delta	59.0					59.0	**59.0**
Upper Egypt			31.5	6.2	186.2	223.9	**184.0**
High Aswan Dam		3.6	160.1	342.5	275.5	781.6	**195.0**
Lake Shores		9.0			41.0	50.0	**0.0**
Sinai	102.5			111.6	29.5	283.6	**212.0**
Total	**471.5**	**183.8**	**375.8**	**568.8**	**1,281.8**	**2881.7**	**1,526.0**
With Groundwater							
New Valley	1.5	62.5	14.2	5.2	484.5	562.7	
Sinai			2.0			7.2	
Total	**1.5**	**62.5**	**16.2**	**5.2**	**484.5**	**569.9**	**82.0**
Grand Total	**478.0**	**246.0**	**392.0**	**574.0**	**1,766**	**3,451.6**	**1,608.0**

* Feddan = 4200m2 = 0.42 ha = 1.038 acres.

Table 5 gives the area of land that could be reclaimed using the Nile water and groundwater as 2.88 million feddans and 570,000 feddans, respectively. Therefore, the total area of re-claimable land, mainly in the Nile Valley and Delta, is of the order of 3.45 million feddan.

However, land reclamation has been a controversial issue because of the large investments in, and poor performance of, large-scale schemes during the 1970s. A World Bank report (1989) identified several reasons for the poor performance:

(a) lack of planning and project implementation,

(b) inadequate knowledge of the soils,

(c) need for a different construction technology for sandy soils,

(d) weak post-implementation assistance in extension, training, etc.

Thus, lands which were not fully reclaimed and developed were cultivated, giving rise to drainage and water-logging problems. The same report goes on to conclude: “A number of the problems which impacted on earlier land reclamation have been resolved. The implementation of physical land reclamation has become a relatively straight-forward, trouble-free technical exercise”.

Properly planned and executed land reclamation, which appears unavoidable in Egypt, is quite compatible with the concept of sustainable agriculture because of the extremely scarce and limited land resources.

2.2.4 Forest Resources

The Food and Agriculture Organization of the United Nations (FAO) in its Global Forest Resources Assessment for the year 2000 (FRA 2000) estimated the forest area of Egypt to be nil or 0% in other words. FRA 2005 estimated the extent of plantation forests in Egypt to be 67,000ha representing 0.1% of the land area with 50% of this area as protection forests and 48% has a multiple function (i.e. protection and production function). This is of course quite natural when considering the fact that the whole country lies within the Great Sahara Region in Africa.

2.3 Human Resources:

Since man is the engine and aim of socio-economic development, Egypt focuses on investment in human capital through education training and extension to improve the knowledge, skills and abilities of the workforce.

Egypt’s population was estimated at 67.313 million people (2003) living on almost 5% of its national territory[6]. Population density varies among the governorates. Approximately 17% of the Egyptian population lives in Upper Egypt. The rest are distributed between Lower and Middle Egypt. The strategy

[6] "Egypt: The Statistical Year Book".

for socio-economic development up to 2017 aims at increasing the inhabited area up to 20-25% of the Egyptian land area through the implementation of the national projects including Lake Nasser areas which are currently under implementation.

The Egyptian rural population represents about 51% of the total population. By the year 2017, it is expected that they will represent 47% of the total population.

In 1995/1996, the Egyptian labor force was estimated at 16.7 million people, representing about 27% of the total population. Agriculture alone absorbs about 4.8 million workers, which constitutes about 31.3% of the total workforce.

2.4 Institutional Framework

2.4.1 Responsibilities of Institutions with Responsibilities for Water Quality

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.

2.4.2 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.

2.4.3 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.

2.4.4 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.

2.4.5 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.

2.4.6 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 is 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.

2.5 Policy Framework

2.5.1 Egypt's Agricultural policy up to 2017:

A Land Master Plan of Egypt was prepared in 1986. it concluded that the construction of AHD not only made the intensification of agriculture feasible in the old lands but also extended it to new "reclaimed" areas. Some 650 000 fedddans out of 805 000 feddans of land reclaimed during 1960-70 was made possible due to the increased supply of water from AHD. The total land that could be reclaimed is subject to water availability. The arable area per person declined by 75%from 0.51 feddan/person to 0.13 feddan/person during 1887-1990 (Abu Zeid and Rady 1991).

The strategy for agricultural development up to 2017 has a number of aims.

(i) To increase the annual rate growth in the agricultural production from 3.4% to 3.8% during the remaining period of the Fourth 5-Year Plan, and to 4.1%

annually up to 2017. This goal is attainable only through vertical and horizontal expansion of plant and animal production, which will have a positive bearing on job creation, income to producers and the overall standard of living of the rural population.

(ii) To reclaim no less than 150 thousand feddans annually, within the master-plan of Egypt's Land and water resources which assesses the reclaimable and cultivable lands in the Delta, Southern Valley, East Owaynat, the area of and round Lake Nasser and East and West of Suez Canal by the year 2017 at about 3.4 million feddans. The inhabited area would reach 25% of the total area of Egypt.

(iii) To increase the agricultural production horizontally and vertically through the efficient allocation and use of soil and water resources. Maintenance and development of the natural resource base is an integral part of Egypt's sustainable agricultural development program.

(iv) To form a national strategic stock of the basis food commodities by focusing on the efficient use of the available resources and redirecting investments to such areas that help fulfill the increasing food needs of the population. This shall be accompanied with rationalization of food consumption levels, reduction of post-harvest losses.

2.5.2 Water Policy

The Ministry of Water Resources and Irrigation (MWRI) has prepared a National Water Policy till the year 2017 including three main themes:

- optimal use of available water resources;
- development of water resources; and
- protection of water quality and pollution abatement.

At present, Egypt is addressing the issue of limited water quantity by managing the demand side. MWRI formulated a water master plan in 1981. This plan is currently updated. The process of updating the water master plan aims to allocate available water resources according to various needs and demands that are feasible from the economic perspective. It also aims to gain social acceptance and political support. The Water Master Plan is updated through the National Water Resources Plan (NWRP) project.

The NWRP has been operated since 1998 and jointly funded between MWRI and the Netherlands Government. This project is directed towards developing a National Water Resources Plan that describes how Egypt will safeguard its water resources both quantity and quality and how it will optimize the use these resources in response to the socio-economic and environmental conditions.

3. GENERAL CHARACTERISTICS OF LAKE NASSER/NUBIA

3.1 Introduction

The Nile is the longest river in the world, stretching around 4.200miles. Ancient Egypt would not have existed if it weren't for this mighty river. "Egypt is the gift of the Nile", wrote the Greek historian Herodotus in the fifth century B.C. No. other country owes its very existence to a single lifeline" (El-Sayed and van Dijken, 1995). The runoff from the summer rains in the Ethiopian Highlands causes the annual summer flood of the Nile that the Egyptians depended on for water to irrigate their crops, and deposit fertile topsoil. This annual flood was the major reason that the areas surrounding the Nile became habitable. But at the turn of the 20^{th} century the growth of population had well exceeded agricultural production. The Nile had to be controlled if there was going to be agricultural stability along its banks.

The only way to control this mighty river was to erect a dam. The first of the dams was the Aswan Dam, which was built by the British and completed in 1902, constructed 3 miles from the city of Aswan. It was the chief means of storing irrigation water for the Nile valley. The Aswan Dam's height was raised in subsequent building campaigns of 1907-12 and 1929-34. Even after these campaigns, the dam proved to be insufficient because it was necessary to open the sluices to relieve the water pressure building up against the dam. This caused tremendous amounts of damage downstream, flooding the areas that were supposedly protected. It was then decided that a second, larger and more effective dam was necessary. So in the early 1950s, designs began to be drawn for what was to become the Aswan High Dam. The construction of the Aswan High Dam had many effects on Egyptian life, agriculture, and the environment (Schall, 2001).

The Dam supported a very high population growth rate because it expanded agriculture, energy, and manufacturing production. Lake Nasser became an important fishing site, supplying food and livelihood for the population around it (Dubowski, 1997). Also, the agriculture and farming industry of Egypt was also directly impacted from the construction of the Dam. There were positives, and negative effects resulted. One of the positive effects on agriculture was that crops could be grown year round. The High Dam created a 30% increase in the cultivable land in Egypt.

The northern two-thirds of the lake, lying in Egypt, is named for Gamal Abdel Nasser, president (1956-70), and the southern third, in The Sudan, is called Lake Nubia. Before Lake Nasser was formed, the area was the site of the temples of

Abu Simbel, which were built by Egyptian pharaoh Ramses II in the 1200s BC. During the construction of the Aswan High Dam in the 1960s these temples were moved, but many other historic monuments were submerged. Also submerged is a portion of the historic lands of the Nubians, who lived along the Nile between Aswan and Khartoum, Sudan, for thousands of years.

Due to the reservoir's large storage capacity, which approximates the flow of the Lower Nile over a two year period, the project's three major goals of hydropower generation, flood management, and completing a shift from flood-based or basin to perennial irrigation have been realized. According to financial data collected by Biswas (2002)[7] the costs of the project were paid off within two years, while Shenouda (1999) estimates that increases in agricultural productivity alone paid for the financial costs of the dam within several year period. Even if such estimates exaggerate returns, when one adds the income from agriculture, generation of hydropower, and flood management, the financial success of the project is clear.

3.2 Physical Setting

3.2.1 Relief and Drainage

The Aswan High Dam Reservoir (AHDR) extends some 500kms from the southern part of Egypt across the border into the northern Sudan (where it is known as Lake Nubia). The lake extends some 320kms in Egypt and 160kms in Sudan[8]. The average surface area is approximately 6,000km2. At 183masl water level the reservoir contains 168.9km^3. The water level fluctuates between 147 to 182 masl during one year and from year to year. The total capacity of the reservoir consists of the dead storage of 31.6km3 (85 to 147 masl lake level), the active storage of 89.7km3 (147 to 175masl), flood control storage of 16.2km3 (175 to 178masl) and maximum surcharge storage of 31.4km3 between 178 to 183masl (MoWRI).

Higher relief is found on the eastern side of the basin (Map 2). In the southwest the watershed is of low relief with the Tushka Depression lying to the west. In the northeast the watershed has much higher relief. At very high levels the lake now discharges in to the depression.

A number of wadis with catchments of some considerable size are found in the southeast. The largest of these is the Wadi Allaqi, which extends some 250kms along a northwest axis from its headwaters in the Red Sea Hills. The wadi runs

[7] Biswas A.K. 1991. Land and water management for sustainable agriculture in Egypt: Opportunities and Constraints, Project TCP/EGY/0052, Report to FAO, Rome.

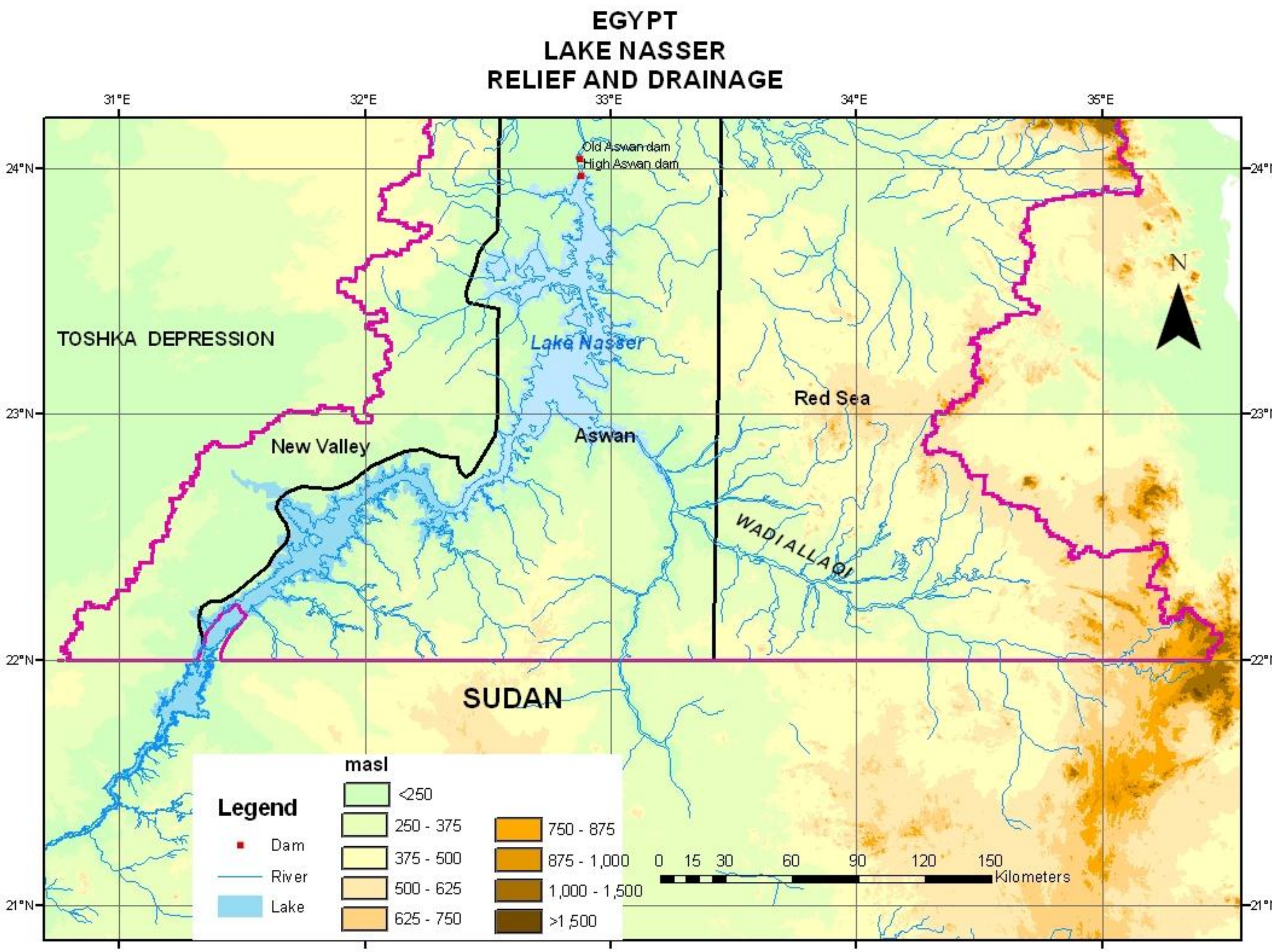
[8] Mohamed El-Moattassem (2004) "Third Report: Sedimentation of Aswan High Dam Reservoir (SMS/Hydrodynamics and SMS/SED-2D Applications)", NRI, Cairo.

very infrequently, although in 1994 the wadi discharged into Lake Nasser for ten days.

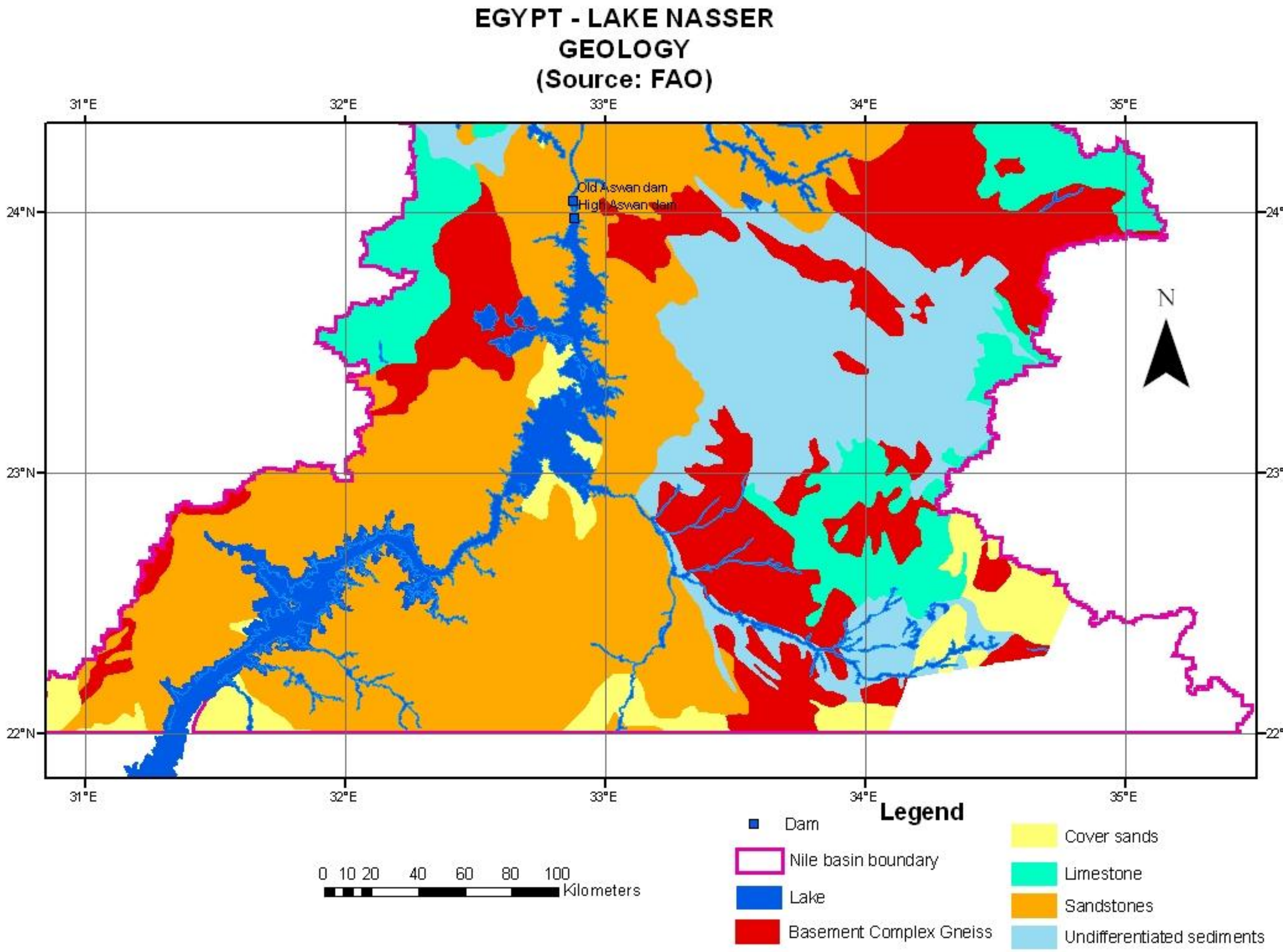
3.2.2 Geology and Landscape

The main underlying geological formations within the Lake Nasser Basin include the older Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands. The Basement Complex comprises gneisses, schists, marbles and intrusive granites and basic rocks. The Nubian Sandstones overly unconformably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates. This formation forms the main groundwater basins in Sudan. The Recent deposits include the Nile alluvium, sand dunes and the black clays of the flood plains.

Several quarrying concessions have been granted in the Wadi Allaqi area. Also the Egyptian Government has given Gippsland Ltd. the right to explore for gold in eight areas of the wadi.



Map 2. **Egypt – Lake Nasser: Relief and Drainage**



Map 3. Egypt - Lake Nasser: Geology (Source: FAO/IGADD)

3.2.3 Land cover

The land cover away from Lake Nasser is mainly bare rock and sand. The distribution of the sand is an important factor in determining the potential sources of drifting sand. Generally the most extensive areas of sand are to the west with most bare rock to the east. The prevailing winds are from the northwest the second major factor, which when combined explain the problem of drifting sand into the Lake.

There is a zoning of vegetation around the Lake from the water's edge. Normally, this stretches only tens to hundreds of meters from the Lake shore but along the Wadi Allaqi this zoning has been stretched over some 30kms from the lowest water mark recorded to the highest (177.5masl)[9]. Annuals characterize the zone closest to the water's edge typically dominated by *Glinus blitoides*, together with *Portulaca oleracea, Helianthemum spinum, Amaranthus blitoides* and the grasses *Erogrostis aegyptica, Fimbrystilis bis-umbellata* and *Crypsis schoenoides*.

In the middle zone *Tamarix nilotica* is dominant. In the central section the stands are mono-specific, and individual plants may be large, exceeding 5 meters. The highest zone is characterized by a vegetative type dominated by the composite shrub *Pulicaria crispa* that replaces *T. nilotica*. It appears to mark the highest levels attained by Lake Nasser. Associated with *P. crispa* are *Acacia ahrenbergiana*, *A. raddiana*, *Cassia senna* and *Citrillus colocynthis*.

A recent study[10] suggests that the *Tamarix nilotica* community is both new and almost unique within this desert area. It has a clear affinity with the flora present in earlier pluvial periods in this area of North Africa. Evidence for this is provided in fossil plant remains found in sand hillocks of the upper wadi Allaqi dated to about 500-800 years BP. There is no record of *T. nilotica* being found in its present position prior to the filling of Lake Nasser other than along the river bank zone.

Burning and cutting of *T. nilotica* by local communities, as well mechanical clearing by the Aswan high Dam lake Authority are leading to its destruction. The upper Pulicaria community is being uprooted by machine and taken by the truck load as fuel.

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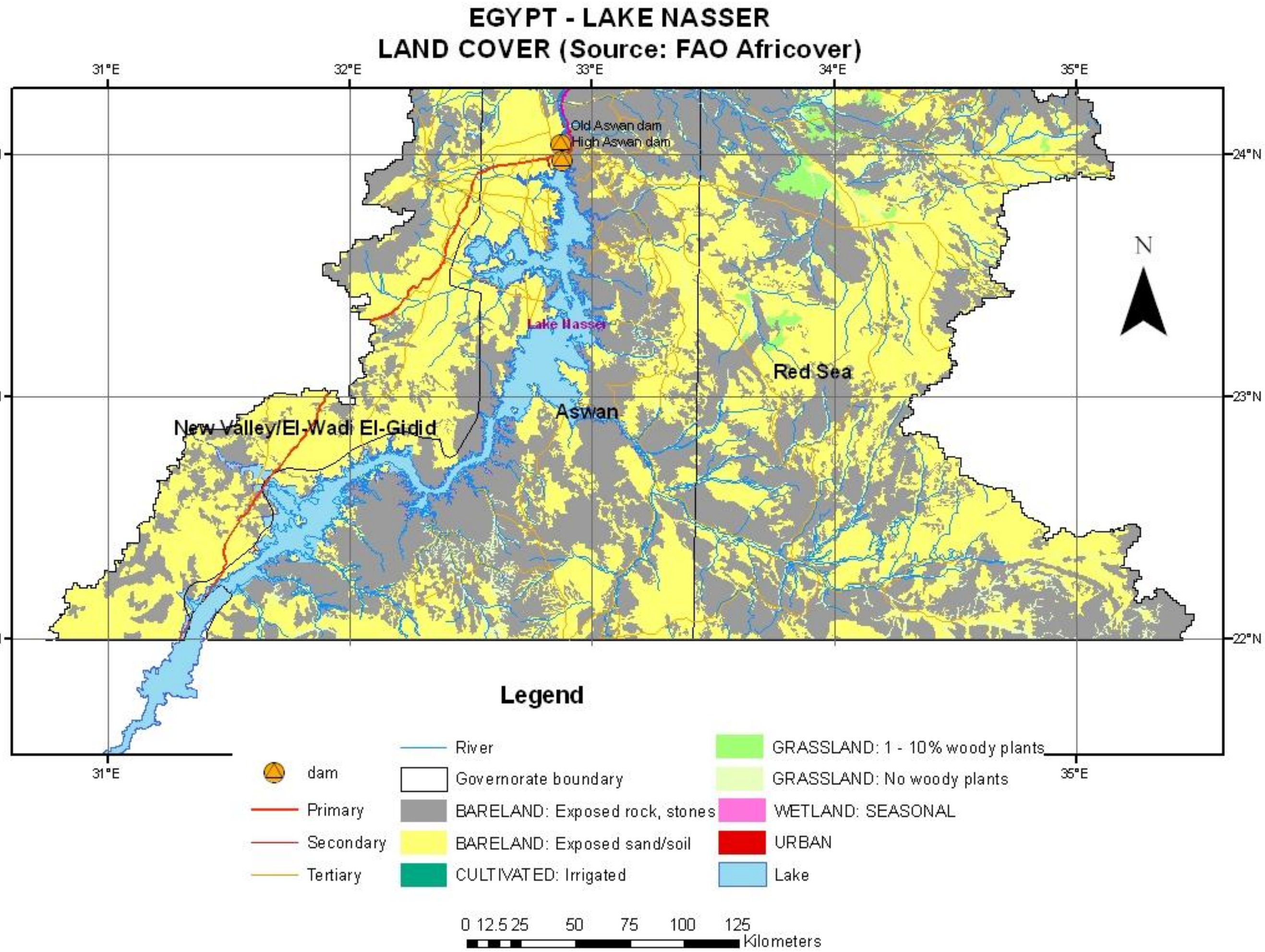
[9] Briggs, J et al (1993) "Sustainable Development and Resource Management in Marginal Environments: Natural Resources and their Use in the Wadi Allaqi Region of Egypt", Applied geography 13, pp. 259-284.

[10] Springuel, I. et al (1997) "The Plant Biodiversity of the Wadi Allaqi Biosphere Reserve (Egypt): Impact of Lake Nasser on a desert wadi ecosystem", Biodiversity & Conservation, Vol. 6, No. 9, pp. 1259-1275.



Map 4. Egypt – Lake Nasser: Land Cover (Source: FAO Africover)

3.2.4 Water Resources

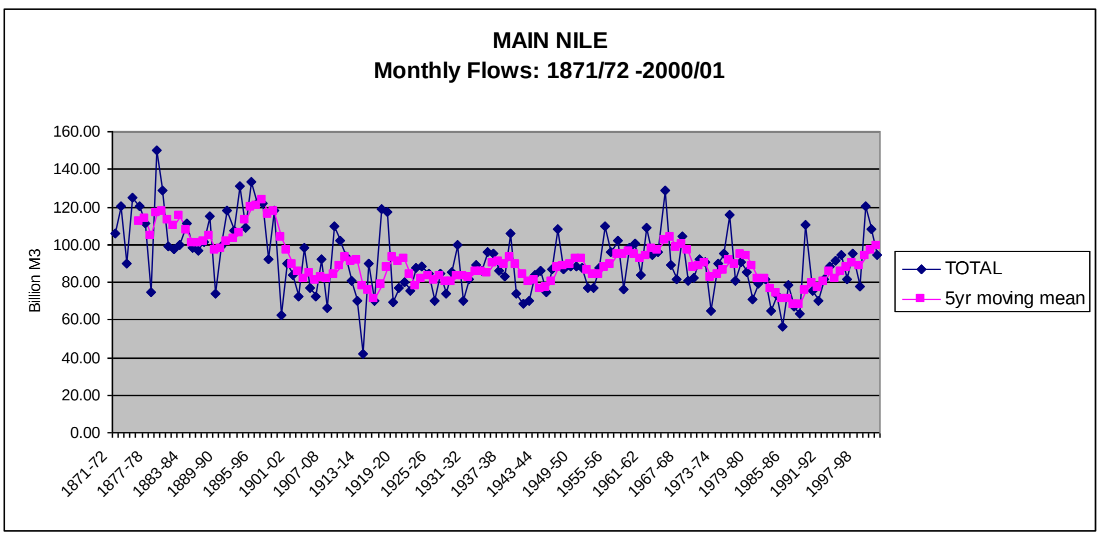
(i) Surface Water

The main source of surface water is the Nile. The seasonal flow pattern exhibits the combined characteristics of the two main tributaries with the seasonal pattern of the Blue Nile superimposed on the regular pattern of the White Nile.

The total annual flow at the border with Sudan has historically been taken (before any significant abstraction) as 84km^3 (1905-1959). However, there is considerable year-on-year as well as periodic variations (fig.2).

From 1871 to 1896 saw a period of high flows, a period that saw high lake levels across East Africa. Between 1901 and 1975 annual discharges averaged around 87km^3. The decade from 1976 to 1987 saw a series of very low flows – average annual flow about 76km^3, since when flows have increased again.

Figure 2. Main Nile: Monthly Discharges and 5 year moving mean.1871/72 -2000/01



(ii) Ground Water Resources

Four categories of ground water basins have been recognized based on the geological formations:

(i) Nubian sandstone basins
(ii) Detrital Quaternary-Tertiary Basins
(iii) Recent Alluvium Basins.

Basement complex rocks only have a limited ground water yield. The Nubian sedimentary formation forms the most extensive and largest ground water basin in Egypt. Although recharge from rainfall is very limited a substantial annual amount is received from the Nile River system. The quality is good to excellent with salinity values rarely exceeding 600mg per litre.

The long axis of the Wadi Allaqi follows fault zone between the basement complex rocks to the northeast and the Nubian Sandstones to the southwest. These are overlain by unconsolidated wadi sediments of Holocene and Recent age when the local climate was wetter. The Wadi floor has a very gentle gradient of 0.5degrees. Groundwater is from two sources. The first is deep percolating water from the Red Sea Hills over which there is varying amounts of rainfall annually. This is normally 30 meters below the surface and of poor quality. The second source of groundwater is from the Lake. This is usually available about 2 to 3 meters below the surface, and is extremely variable because changes in Lake level. (One meter change in Lake level causes a one kilometer change in inundation of the Wadi.) The quality of the water is good.

3.2.5 Soil Types

The dominant soil types around Lake Nasser are shown in Map 5. The most extensive soils are Leptosols on rock and Arenosols derived from the cover sands. Locally Calcisols are found derived from crystalline limestones.

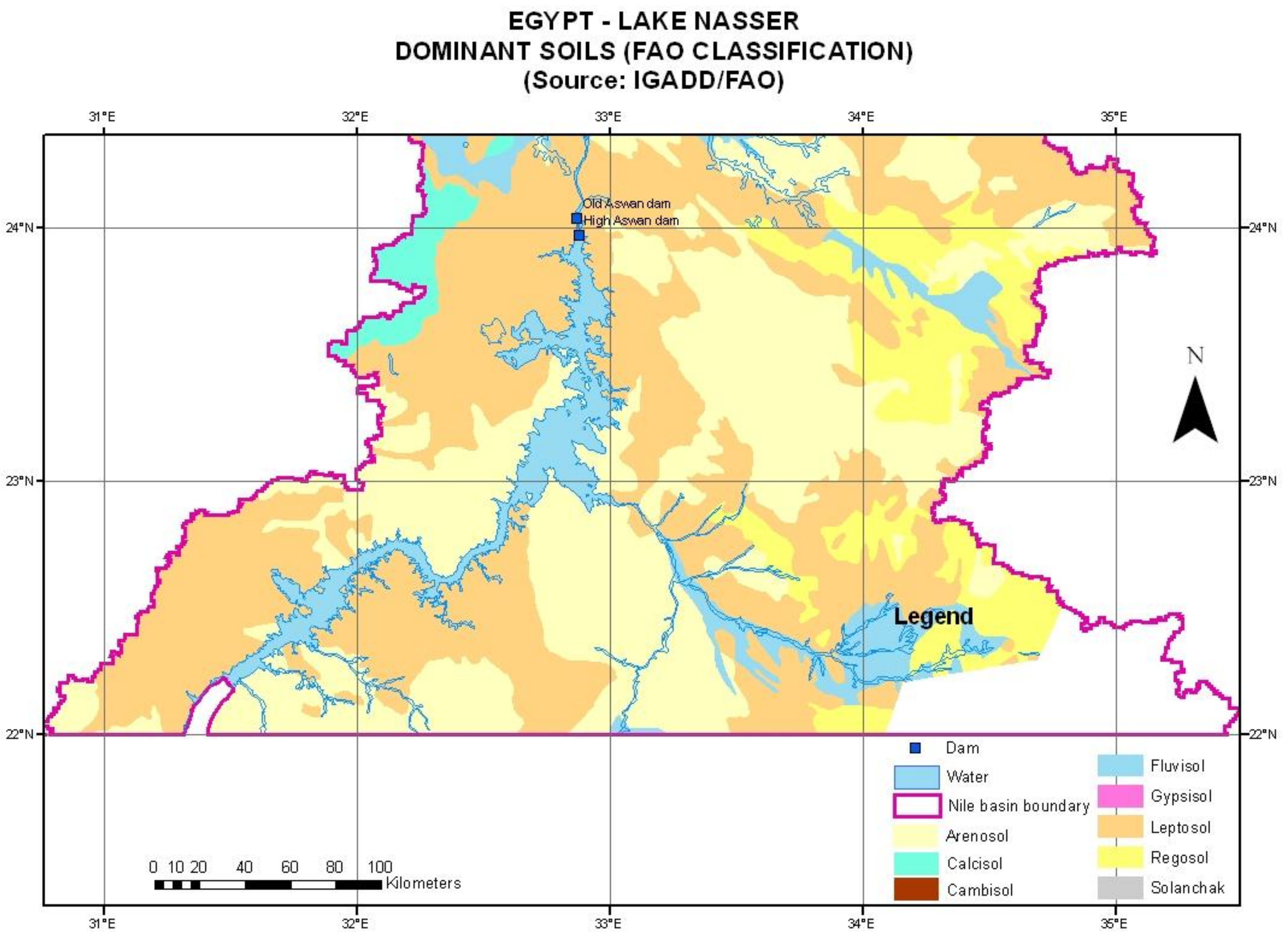
In valley bottoms Fluvisols are very important as they comprise the main soils for irrigation around the Lake shore and in the Wadi Allaqi where they have been intensively studied[11]. Their parent material is from one or more of three sources: sediment in the lake, wind blown sand and flowing water. Laboratory analysis of the soils in the Wadi Allaqi indicated that wind blown sand was the least significant although there is some reworking of fine sediment by wind. Running water (although extremely infrequent) represented the most important source of soil parent material.

The greatest effect on soil quality is the influence of lake water on soil properties. The position of the lake shore is highly variable depending on the annual variations superimposed on larger long-term variations. Annual variations are in the range of 6 to 7 meters, whilst the 1978 -1988 range was 37 meters. Two processes are important: deposition of silt from the lake during inundation and changes in chemistry of the surface soil layers during and immediately after inundation. The lake sediment is identifiable by its high content of shells and may

[11] Biggs, J. et al (1993) op. cite.

contain high amounts of soil nutrients. Soils located at higher elevations and which are inundated less frequently have a lower pH – from 9.00 where the soil is frequently inundated to 8.00 where inundation is less frequent, whilst the subsoil remains constant at 8.8. Less frequently inundated soils also have high oxidized iron contents that could have important consequences of the soil's ability to supply phosphate and some trace elements.

There is little accumulation of organic matter except under Tamarix trees.
Tamarix litter has high salt contents and these build up in the soil due to lack of leaching.

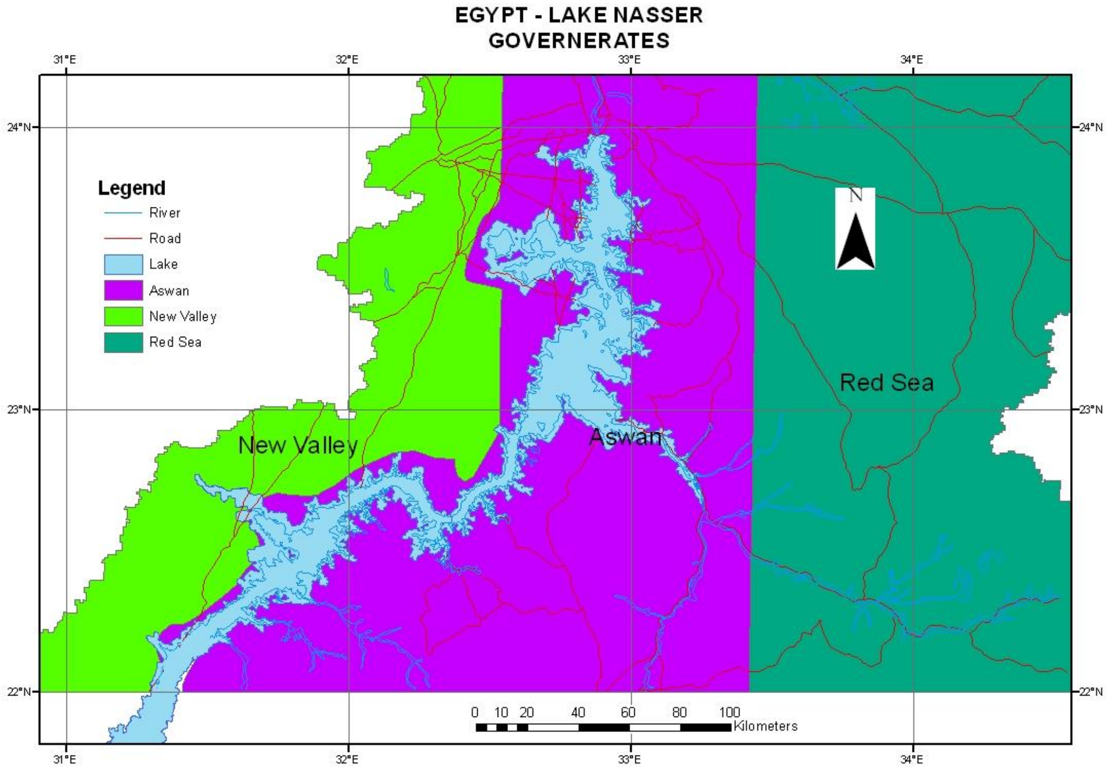


Map 5. Egypt – Lake Nasser: Dominant Soil Types

3.3 Socio-economic Setting

3.3.1 Administrative Structure and Population

The Lake Nasser basin encompasses three Governorates: Aswan, New valley and Red Sea. The key Governorate for the Lake itself is Aswan with its capital in the town of Aswan.

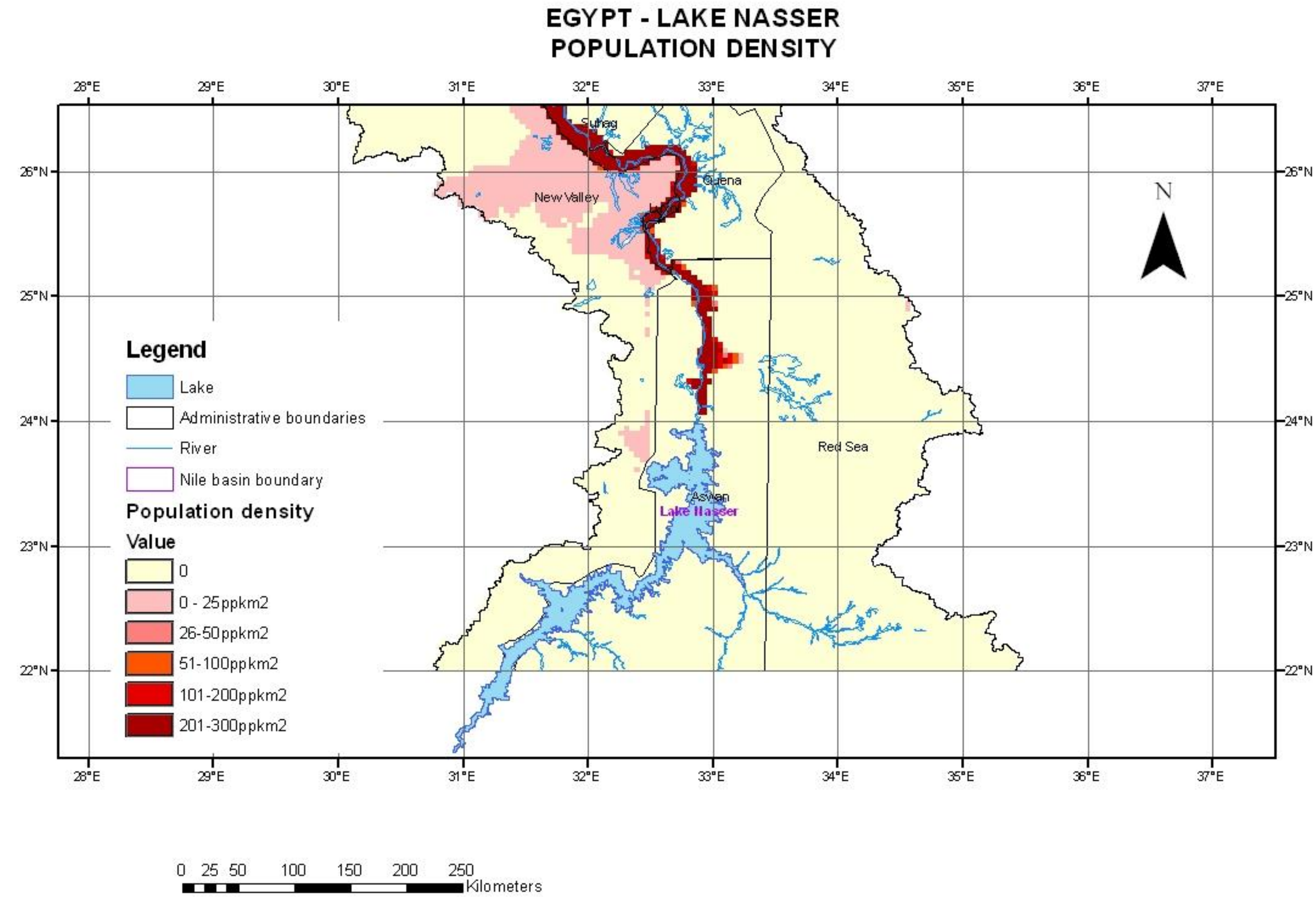


Map 6. Egypt – Lake Nasser: Administrative Structure

Table 6. Total Population and Area within the Sub-basin by Governorate (2005)

GOVERNERATE	2005 Population	Area (km2)
Aswan	169,647	45.886
Red Sea	1,120,275	69.630
New Valley	186,375	61.142

The population in concentrated along the Nile Valley with the desert beyond almost totally un-inhabited. This shown in Map 7.



Map 7. **Egypt – Lake Nasser: Population density**

3.3.2 People and Livelihoods

(i) The Ababda and Bishari

There are two main ethnic groups who live in the eastern part of the Lake Sub-basin: the Ababda who comprise some two thirds of the population and the Bishari who make up the other third. The Ababda have live in the southern part of the Eastern Desert for centuries although since the end of the 19th century many have migrated to the towns of the Nile Valley. The current population is estimated to be 15,500.

The Bishari are more recent arrivals. Traditionally they lived in the Gebel Elba Region in the Red Sea Hills along the border with Sudan. Most have arrived since the 1970's to take advantage of the opportunities presented by the seasonal inundation.

There is little difference between the livelihoods of the two groups. Their economy is based on five elements[12]. In order of preference these are: (i) charcoal production, (ii) sheep herding, (iii) camel herding and (iv) collecting medicinal plants, and (v) residual moisture cultivation.

There are seasonal differences: with charcoal production and sheep herding taking place between December and April, cultivation between May and September, and camel herding and medicinal plant collection throughout the year. In the hill areas to the east winter rains are common and people migrate there for sheep herding and charcoal production. One person can produce five sacks of charcoal at £E50 (US$14 at 1993 prices) a sack. For a production unit of three people over a four month production season this can realize an income of E£3,000 per household. Overheads are negligible and harvesting is reported to be sustainable. Sacks are transported to Allaqi by camel and then either sold to truck drivers of a local quarry, AHDLA or WFP, or get lifts on such lorries.

In the summer they return to Lake shore to take advantage of the cooler temperatures near the lake and the retreating lake for cultivation of the residual moisture and the grasses that grow on the moisture. This system of seasonal transhumance allows the forage resources in the hills and in the lower Wadi Allaqi to recover. However, the attractions of the Lake shore and lower Wadi inundation area means that movements to the hills are getting shorted putting a strain of the forage resources near the lake.

[12] Briggs, J. et al (1993) "Sustainable Development and Resource Management in Marginal Environments: Natural Resources and their Use in the Wadi Allaqi Region of Egypt", Applied geography (1993) Vol. 13, pp. 259-284.

Cultivation depends initially on residual moisture but as the season progresses on well water. Cultivation takes place in fenced plots 50 by 50 meters. Most plots have more than one well. Wells deeper than 3 meters are avoided because of the labour involved. Most wells are only used for one season as they are frequently inundated the following rise in Lake level. Small gardens of 5 by 5 meters are constructed within the plot and fed by small canals from the well. Crops include maize, water melon, okra, marrow, beans and millet.

Camels roam freely and are not herded and can roam for up to six years. Medicinal plant collection is carried out locally as and when time permits.

(ii) *Dabuka* (Camel trains)

Since inundation started in the early 1970's the Wadi Allaqi has become a major stopping over point for the *dabuka* (camel) trains from Sudan. Abu Hamed and Atbara are the main collecting points for the journey of 10 to 11 days following the Wadi Gabgaba for much of the way to Wadi Allaqi. The final journey of 3 to 4 days is to Daraw, north of Aswan where most camels are slaughtered for meat.

The Wadi Allaqi, because of the arm of Lake Nasser extending into the wadi fullfills a major role in this system. Although a healthy camel can go for 14 days without water, a ten day journey should present no problem. In practice the available water in the Wadi Allaqi is extremely important for the maintenance of camel and thus meat quality.

It is estimated that 100,000 camels in over 300 *dabuka* a year make the journey from Sudan by this route. Economically the dabuka drovers provide a source of trade, a means of transport to Aswan and Daraw and a source of information of the location and quality of pastures through the areas they have traversed.

(iii) Other Cultivators

After 1988 reservoir levels began to rise, with full storage levels again reached during the 1990s. In 1989 the World Food Program (WFP) agreed to launch a joint program with the High Dam Lake Development Authority whereby WFP would provide food for work to reclaim land along the lake shore for agriculture as well as for the eventual construction of 33,000 houses (Poeschke 1996). By the mid-1990s 10,000 feddans had been reclaimed in three upper reservoir areas that Nubians had first attempted to pioneer in the late 1970s. Nubians, however, are only one of the people involved; others included non-Nubian fisher/farmers from Upper Egypt as well as Beja pastoralists from the eastern desert and the Red Sea coast who have begun to graze and water their stock around the edges of the reservoir. Whether or not the Nubians, as the former residents of the area, will be able to compete successfully against these other pioneers remains to be seen.

(iv) Fishing

To reduce conflicts among the fisher people the Egyptian portion of the reservoir was divided into five sections based on fishers' areas of origin (Sorbo 1977). During the next six years numbers increased. By the end of the project fishers numbered approximately 5,000. These were Saiydis, (an upper Egyptian peasant population), from two governorates with a long history of fishing immediately north of Aswan and a few Nubians being fishers even in Old Nubia.

Though more transport boats had been added along with refrigerated railway cars to continue to Lower Egypt, the state of the fishery remained much undeveloped with fisher people living either in their boats or in temporary shelters in 150 fish camps. Estimated landings were 10,000 tons per annum. Potential of the inshore fishery at the then reservoir level of 160 meters was estimated at 12,000 tons rising to 23,000 tons at full storage level.

(v) Tourism

Adding Lake Nubia to tourist destinations around Aswan has considerable potential, especially during the winter months. Already the rebuilt Abu Simbel temple complex is a major tourist attraction by both boat and plane. In 1989 the Government began cooperating with UNESCO in making other archaeological sites available to local and international tourists. During the salvage operations of the 1960s these had been grouped in three locations, the first being close to the western end of the dam and the other two also on the west bank-approximately 100 and 200 kilometers up the reservoir from Aswan. The first site is already accessible as the other two will be once connecting roads are built from the now tarred Aswan-Abu Simbel highway. As for the town of Abu Simbel, by the mid1990s it had a total population of approximately 5,000 people.

3.4 Agriculture and Farming around Lake Nasser

3.4.1 Introduction

Due to the extensive length of Lake Nasser shores, vast areas surrounding the reservoir, above the Lake water level are reclaimable and suitable for agro-industrial projects. Other low-wet shore lands are seasonally flooded and can be planted for about 9 months per annum.

3.4.2 Cultivated Area:

The most recent data regarding agriculture and farming of and around Lake Nasser show that the total agricultural area is 12,970 feddans, 6,767 feddans are cultivated and 6,203 feddans are uncultivated (March 2006). These areas are located around the lake as shown in table 7.

Table 7. Land use around Lake Nasser, 2006.

Location on Lake Nasser	No. of Groups of beneficiaries*	No. of persons*	Agriculture area		Total area feddan
			Cultivated	Uncultivated	
East	53	159	1073	900	1973
North	166	471	3356.5	835.5	4192
South	95	379	2338	4467	6805
Total	**314**	**1009**	**6767.5**	**62025**	**12970**

Source: General Authority for Development of AHD Lake (GAD-AHD-Lake), 2006 (High Dam Development Authority), Agricultural Sector

* Number of settlers

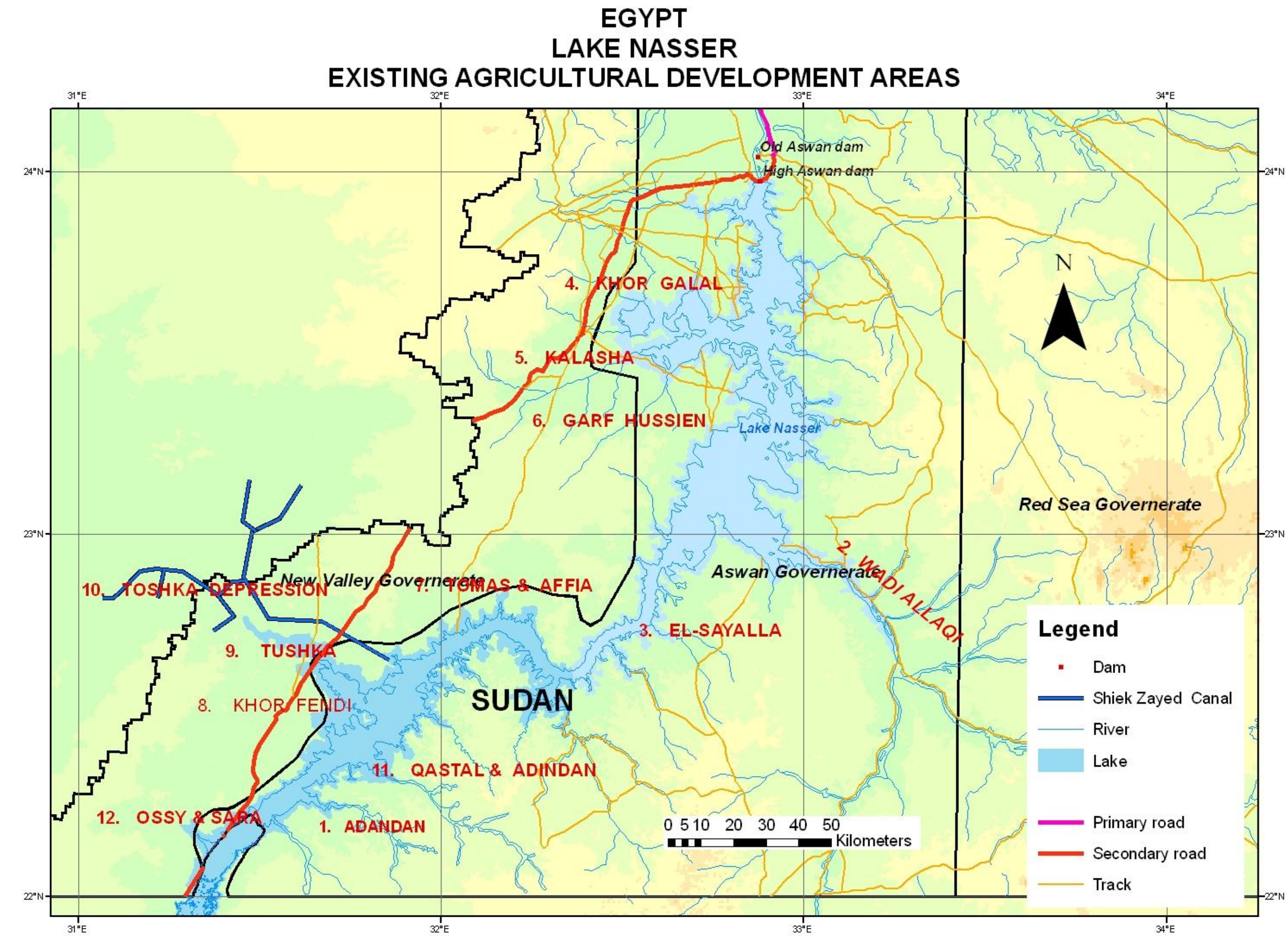
These three locations and the distribution of groups and persons are presented in Table 8 according to the different zones within each location.

Table 8. Zones within locations on Lake Nasser shores and cultivated areas, 2006.

Location on Zone	Groups	Persons*	Agriculture area feddan		Total area feddan
			Cultivated	Uncultivated	
A. East	53	159	1,073	900	1,973
Dahmeet	1	3	40	-	40
El-Alaki	23	79	485	260	745
El-Sayalla	29	77	548	640	1,188
B. North	166	471	3,357	835	4,192
Khor Galal	15	54	335	37	382
Kalabsha	67	211	1,417	68	1,486
Garf Hussien	51	145	843	620	1,473
Tomas &Affia	33	70	742	110	852
C. South	95	379	2,338	4,467	6,805
Khor Fendi	32	134	577	1,070	1,647
Tushka	34	114	1,291	1,042	2,334
Tushka	10	43	429	2,100	2,529
Depression	19	88	41	254	295
Qastal & Adindan	-	-	-	-	-
Ossy & Sara					
Total	**314**	**1,009**	**6,768**	**6,203**	**12,970**

Source: General Authority for Development of AHD Lake (GAD-AHD-Lake), 2006 (High Dam Development Authority), Agricultural Sector

* Number of settlers



Map 8. **Egypt – Lake Nasser: Existing Agricultural Development Schemes.**

3.4.3 Cropping Pattern (Winter 2005/06) for areas of and around Lake Nasser:

Plants grown by farmers around Lake Nasser as shore farming are field crops, (551 feddans), vegetables (3,427 feddans) and medicine and aromatic plants (15.5 feddans); as shown in table 9.

Table 9. Cropping Pattern of cultivated areas of and around Lake Nasser during 2005/06 Winter season (October- May).

Crop	Area feddan
A. Field Crops:	
What	323
Onion	28
Faba bean	28
Egyptian clover	50
Fenugreek	7
Lupin Termes	13
Corn (Zea mays)	102
Sub-Total	**551**
B. Vegetables:	
Tomatoes	1,049
Eggplant	200
Sweet Pepper	248
Water melon	1,415
Cucumber	163
Squash	269
Cantaloupe	73
Sub-Total	**3,427**
C. Medicine & Aromatic plants	**16**
Total	**3,984**

Source: (1) See Table 4.1; (2) Aswan Agric. Directorate.

3.4.4 Crop productivity of Lake Nasser shore Farms:

Table 10 shows the productivity of different crops in the areas of and around Lake Nasser as compared to that of Aswan Governorate during 2004/05.

Table 10. Average crop yields of farms around Lake Nasser and Aswan Governorate crop yield averages (2004/06).

Crop	Average Yield (ton/feddan)		Difference Ton/fed.	% decrease
	Aswan Governorate	Lake Nasser		
Wheat	1.5	1.35	0.15	10
Egyptian clover	20.0	15.0	5.00	25
Onion	4.0	4.0	0.00	0.0
Corn	1.35	1.5	(0.15)*	(+11)
Faba bean	0.70	0.7	0.00	00
Tomatoes	12.00	18.0	(6.0)	(+50)

Pepper	4.5	4.0	0.5	11
Cantaloupe	4.3	3.0	1.3	30
Water melon	11.5	12.0	(0.5)	(4.3)
Cucumber	4.5	5.0	(0.5)	(11)

* Figures in brackets are higher in Lake Nasser area.
Source: Aswan Governorate Agriculture Directorate; HD Development Authority.

From table 7 it is clear that yield of wheat, clover, pepper and cantaloupe are on the average less than the average yield for Aswan governorate by 10%, 25%, 11% and 30% respectively. While that for corn, tomatoes, water melon and cucumber was higher than that for Aswan governorate by 11%, 50%, 4.3% and 11%, respectively.

3.5 Livestock Wealth:

Table 11 shows that the total number of animal heads is 24,544. They include 15,279 head of sheep (62.25%) 6,146 head of goats (25%), 2,583 head of camels (10.5%), 20 heads of cow and 9 buffaloes, as well as 197 donkeys.

Table 11. Livestock wealth around Lake Nasser (2006).

Type	Number	%
Sheep	15,279	62.25
Goats	6,146	20.04
Camels	2,583	10.50
Cow	20	
Buffalo	9	
Donkey	197	0.80
Total	**24,544**	

Source: General Authority of High Dam Lake Development (March 2006), Agricultural Sector.

Table 12 shows the distribution of animal wealth among different areas villages around Lake Nasser. About 78% of the animal heads are owned by Nomads, and 22% are owned by beneficiaries. Animals are fed on crop residuals and grazing on the natural plant cover in the area and around khors.

Table 12. Livestock wealth distribution in the villages and areas around Lake Nasser (March, 2006).

Village/Zone	Number of heads	%
Kalabsha	2,325	9.47
Garf Hussien	1,035	4.22
Khor Galal	383	0.02
Tomas & Affia	1,025	4.18
El-Alaki	4,234	17.25
Episco	3,213	13.08
El-Sayalla	2,382	9.71
Qastal & Adindan	2,689	10.95
Khor Fendi	2,866	11.67
Tushka	2,088	8.51
Tushka Depression	2,865	11.67
Ossy &Sara	642	0.03
Total	**24,544**	**100**

Source: See Table 4.5.

3.6 Fisheries in Lake Nasser

The fisheries sector and activities in Lake Nasser is under the control of the General Authority of HD Development (GA-HDD). There are four major Fishermen Associations comprise about 5000 fishermen, have been earning a livelihood on the lake.

Measuring 1.25 million feddans, with some 32 species of fish to its name, Lake Nasser was providing adequate supplies until the early 1980s, when production started to plummet. Over the last two decades fishermen have proceeded with their work despite the steady decrease in the quantity of fish they produce—from 34,000 tons in 1981 to a mere 8,000 in 2000. Recorded total fish catch during 2004 was 12434 tons, and 15285 tons during 2005 (Table 13).

Table 13. Lake Nasser Fish Production (Ton), 1966-2005

Year	Total	Year	Total
1966	751	**1986**	**16,315**
1967	1,415	**1987**	**16,815**
1968	2,662	**1988**	**15,888**
1969	4,670	**1989**	**15,650**
1970	5,676	**1990**	**21,882**
1971	6,819	**1991**	**30,838**
1972	8,343	**1992**	**26,219**
1973	10,587	**1993**	**17,931**
1974	12,255	**1994**	**22,074**
1975	14,635	**1995**	**22,058**
1976	15,791	**1996**	**20,540**
1977	18,471	**1997**	**20,503**
1978	22,725	**1998**	**19,203**
1979	27,021	**1999**	**13,983**
1980	30,216	**2000**	**8,281**
1981	34,206	**2001**	**12,164**
1982	28,667	**2002**	**22,093**
1983	31,282	**2003**	**17,029**
1984	24,534	**2004**	**12,434**
1985	26,450	**2005**	**15,285**

Source: GALD, Fisheries Department.

The most important species in the fish landings in AHD are *cichlidae* with *Tilapia nilotica* and *Tilapia galilaea* forming about 90 % of the total fish landings (Rashid, 1995). Cyprinids *Labeo nilotica* and *L. horie* rank second and together with *Barbus bunni* formed 6 %. The catfish *Bagrus* spp. and the large species *Clarius lazera* is the next rank contributor. The characins *Alestes baremose, Alestes dentex* and the tiger fish *Hydrocynus* spp*.,* centropomids *Lates niloticus*, synodontids and schilbeids, notable for their habitat of swimming upside down at the surface, close the list of predominant species. It has been shown that seasonality plays an important role in fish landing with the period of March to

April, which coincides with the peak spawning of Tilapia in Lake Nasser, being characterized by the highest fish landings.

Concerned about plummeting production figures, in 2000. Law 324, was issued, re-allocated fishing space, giving the fishermen’s associations only 60 per cent, with 40 per cent handed over to six private-sector companies—a move that generated unrest among fishermen, resulting in conflict between the associations and the governorate. The companies, promised to increase production to over 40,000 tons per year by fishing at lower depths and developing breeding farms, thereby exploiting the full potential of the lake (Dena Rashed, 2005).

Lake Nasser is characterized by the existence of many khors and lagoons on its banks. The number of the important khors is 85; 48 on the east bank and 37 on the west bank. Khors are considered suitable habitat for fish rearing due to slow water current and phytoplankton growing in them.

According to 1985 studies, there were 1,683 boats used in fishing in the lake with an average catch of about 10 tons per boat per year. Fisheries studies records 57 different fish species in Lake Nasser, most dominant species are tilapia spp, mainly Nile Tilapia (HD Development Authority, 1981).

The fishing surface of the lake is divided into two fishing areas (zones). Fishing in shallow water khors around the shores, which represents about 20% of the lake surface (about 250,000 feddans). The formation of flood khors and lagoons on and around the lake shores provides natural habitat for Nile Tilapia breeding. Tilapia tends not to migrate from these habitats therefore, restocking the lake with Tilapia fingerlings is one way to increase production and to introduce the aquaculture technology to the lake.

Fishing in deep water represents 80% of the lake surface (around one million feddan). Despite, presence of phytoplankton in deep water very few fish live in deep water. This may need to introduce new deep water fish species to develop fisheries in these areas of deep water in the lake shores and areas around it.

A Japanese study stated that the lake potential is estimated at 80,000 tons per year. The governorate of Aswan information states that 60,000-70,000 tons of fish are yearly smuggled out of the lake. To reach the potential of 80,000 tons, some infrastructures are a must. These include: (i) establish 3 new fish hatcheries, (ii) 3 docks for boats, (iii) ice factories and (iv) fish processing and canning factory.

The GALD aims to promote fish production in Lake Nasser. During year 2005, the Authority released and restocked 17.35 million Tilapia fingerlings in the lake and from Sahra Hatchery (7.7 million), Garf Hussein Hatchery (5.65 million) and Abo Simbal Hatchery (4.0 million).

3.7 Natural Vegetation, Environment and Biodiversity

3.7.1 Natural Vegetation

The area around Lake Nasser is typically desert characterized by its very dry and hot climate. Temperature is very high in summer and moderately low in winter. Rainfall is very rare and erratic and absent for long periods exceeding ten years in some cases. Heavy showers causing sizeable damages are sometimes experienced. The soil is gravely sand and sandy clay at the edges of the lake.
Natural vegetation cover is almost absent because of the climatic and soil characteristics of the area except for the very narrow strip parallel to the lake banks and its extensions which narrow and widen according to the topography and the seasonal flood height.

According to a study carried out by the Public Corporation for the Development of the High Dam Lake of the Ministry of Agriculture and Land Reclamation the woody vegetation in the area is mainly desert scrub including; *Tamarix mannifera* (Tarfa or Abal) which grows very densely and to very appreciable sizes in seasonally inundated areas or in areas which are not regularly inundated to a distance of three kilometers from the lake, *Salsola javanica (G*hazal Tree), *Salsola baryosma* (Khirait), *Acacia ehrenbergiana* (Salam), *Acacia nilotica ,A.nubica, A.seyal, A.radiana, Fedherbia albida, A.laeta, A.tortlis, Silvadora persica, Leptadenia pyrotechnica, Capparis deciduas, Cadaba glandulosa , Maerua crassifolia and Balanites* aegyptiaca. From the air and from the Tarfa seems to grow in a form of a belt along the lake shores.

3.7.2 Assessment of the Extent, Trends and Impact of Deforestation and Desertification

Field staff estimate that fuelwood and charcoal constitutes only 20% of the population's energy needs. For the remaining 80% they depend on kerosene. Tree cutting for charcoal production in the hills to the east of Wadi Allaqi is reported to be currently (1993) sustainable.

It was reported that sand has encroached on the old farm and the Dam Authority farm in Abu Simbel area. In the Egyptian side of the lake there is no serious sand dunes movement problem but drifting sand is blown into the lake. The Dam Authority in collaboration with the Environment Research Institute is undertaking some research studies on wind speed, sand dunes movements, types and quantities of sand, estimates of sand volumes which are deposited into the lake using sand traps in 12 stations on the western side of the lake where there are active sand movements. The purpose of this research is to find the most effective ways of solving the problem.

It has been estimated that the moving sand is 700m^3/km annually. The impact of this is reduced storage capacity of the lake and barrages down stream.

3.7.3 Biodiversity and Natural Flora, Plant Cover and Genetic Resources:

The natural flora and botanic cover of the areas of and around Lake Nasser encompasses a vast range of genetic resources both natural and improved by careful man-selection. Natural genetic resources include within species genetic differences in certain characteristics (i.e. sub-species) and the germplasm of selected species of considerable economic importance. For example medicine and aromatic plants are of major importance. Lake Nasser-Nubia and the main Nile river between Khartoum and Aswan provide important habitat for aquatic flora and fauna.

The Encyclopedia of Southern Valley and Tushka (Egypt, 1999) records about 390 plant species. They belong to different plant families as follows: 50 species belong to the legume family, 65 species of grasses, and about 275 species belongs to 55 different plant families. A description and listing of the plant species-ecosystem in the Nubian Nile and Lake Nasser area as well as their usage is shown in Annex 1.

It is important to conserve the Main Nile around Lake Nasser/ Lake Nubia species biodiversity. The conservation of species biodiversity is mainly dependent on the conservation and protection of habitats and the maintenance of ecosystems integrity. It is necessary to consider in-situ and ex-situ conservation. It is important to further study current ecosystems of natural resource base, use and management (formal and informal) and the role of the natural ecosystem in relation to agriculture. Pastoral systems of production should be studied in order to better manage the natural recourses in an effective sustainable way.

Part of the Wadi Allaqi was declared a Protected Area in 1989 by the under the auspices of the EEAA and a "Man and the Biosphere" (MAB) Biosphere Reserve in 1993. It has a core area of 63,850ha, buffers zones of 131,095ha and a transition zone of 2,184,200ha. From an ecological perspective, the reserve and its component zones form an integrated unit based on linear channels of the wadi system, which have physiographic, hydrological and ecological integrity. The small and scattered groups of Ababda and Bishari form an essential component of the Biosphere Reserve[13].

A plant biodiversity study undertaken within the Reserve[14] found a total of 78 plant species and four principal groups, one of which was new to the area. This

[13] UNESCO - MAB (2005) "UNESCO-MAB Biosphere Reserves Directory: Egypt".
[14] Springuel, I. et al (1997) op. cite

latter group is a result of the profound environmental changes occasioned by the flooding of Lake Nasser and its encroachment up the Wadi Allaqi. The new group was indicated by *Tamarix nilotica*. Ground-water dependence appeared to be important in defining a group indicated by *Acacia tortilis* as well as the Tamarix group. The two remaining groups, characterized respectively by *Acacia ehrenbergiana* and *Cullen plicatum* are precipitation-dependant and thus tolerate drier conditions within the Allaqi system.

3.7.4 Aquatic ecology

According to Latif (1984)[15] the phytoplankton in the AHD Reservoir consists largely of:

(i) blue-green algae constituting 95 % in August 1976 and 81 % in October 1979 of the total phytoplankton;

(ii) diatoms with up to 66 % in November 1988 but only 2 %, respectively in August 1988;

(iii) green algae with up to 8 % in November 1988 and 3 % respectively in August 1988.

In the AHD the diatoms were dominant in cold winter months whereas the heat tolerant blue-green algae were found to be dominant in summer (Ahmed et al.[16], 1989; Mohammed et al., 1989[17]). The general conclusion was that the diatom population is replaced by the green-algae as the temperature gradually rises, which in turn are succeeded by blue-green algae. Diatoms and blue-greens were the most dominant groups although their distribution and abundance were affected by thermal stratification and floods (Mohammed et al., 1989).

The undesirable blue-green algae species *Cyanophyta*, typical an impoundment organism, was found predominant in the northern sector of the AHD (Abu-Zeid,

[15] Latif F.A. (1984) "Lake Nasser: the new man-made lake in Egypt (with reference to L Oake Nubia)" in Taub, F.B. (Ed) "Ecosystems of the World 23, Lakes and Reservoirs (pp385-410), Elsevier Publishing Co.

[16] Ahmed, A.M. et al (1989) "Field and Laboratory Studies on Nile Phytoplankton in Egypt 3: Some Physical and Chemical Characteristics of Aswan High dam (Lake Nasser)", International Rev. Der Gesampten Hydrobiologie 74: 313-355.

[17] Mohammed A.A. et al (1989) " Field and Laboratory Studies on Nile Phytoplankton in Egypt 4: Phytoplankton of Aswan High dam Lake (Lake Nasser)", International Rev. Der Gesampten Hydrobiologie 74: 549-578.

1987)[18]. Capable of nitrogen fixation and representing a dead end in the food chain, they cause taste and odor problems.

The zooplankton in Lake Nasser is described to belong to the common group of *Copepoda, Cladocera* and *Rotifera* (Rashid, 1995)[19]. In the main channel and side bays, *Copepoda* is the dominant zooplankton with 72 and 75 %, respectively, followed by *Rotifera* with 17% in main channel and 10 % in side bays and *Cladocera* with 11 % in the main channel and 15 % in side bays (Rashid, 1995).

The *chironomid* (benthos) fauna is rich in the shallow lacustrine areas of the lake. In the semi-riverine section their abundance decreases, and in the riverine section, the *chironomids* are replaced by *ephemeropteran* (mayflies) larvae whereas the bottom *oligochaetas* are replaced by bivalves (Rashid, 1995). The abundance of all mussels in Lake Nasser was massively reduced during the first year of the reservoir formation as a result of oxygen-free bottom conditions. Even under low oxygen conditions, an increase in the biomass of *oligochaetes* observed after 1973. This was possible due to their ability to withstand oxygen deficiency for several weeks or months, being able to utilize the high organic matter content of the sediment (Entz, 1980a)[20].

The fish population of the AHD Reservoir is dominated by 9 families. A list of the families and the main species is given in Table 14. The fish abundance and distribution in AHD is described to vary among the different sectors of the reservoir and side-bays. Many factors play an important role in the fish population and density as the migration of certain type of fish is dependent on the arrival of the turbid flood water, the preference of riverine or semi-riverine conditions, reproduction habitats and spawning or food and feeding habits.

The fish food items in the AHD Reservoir are periphyton, phytoplankton and zooplankton, insects larvae (chironomids), gastropods, bivalves, juvenile fishes and fresh water shrimps (Rashid, 1995).

Table 14. Egypt – Lake Nasser: Major Fish Families and Species

	Family	Species
1	Cichlidae	*Tilapia nilotica* *Tilapia galilaea* *Tilapia zilli* *Oreochromis aureus* *Sarotherodon galilaeus* *Oreochromis niloticus*

[18] Abu Zeid, M. (1987) "Environmental Impact Assessment for the Aswan High dam ", in Biswas, A & Q. Geping (Eds) "Environmental Impact Assessment for Developing Countries" (pp168-190).

[19] Rashid, M.M. (1995) "Some additional information on limnology and fisheries of Lakes Nasser (Egypt) and Nubia (Sudan)" in CIFA Technical paper No. 30, FAO, Rome.

[20] Entz, B./A.G. (1980) "Ecological aspects of Lake Nasser-Nubia" Water Supply & Management 4: 67-72.

2	Centropomidae	*Lates niloticus*
3	Characinidae	*Alestes nurse*
		Alestes baremose
		Alestes dentex
		Hydrocynus forskahlii
		Hydrocynus lineatus
		Hydrocynus brevis
4	Cyprinidae	*Barbus bynni*
		Labeo niloticus
		Labeo coubie
		Labeo horie
5	Bagridae	*Bagrus bayad*
		Bagrus docmac
6	Clariidae	*Heterobranchus bidorsalis*
		Clarias lazera
7	Schilbeidae	*Eutrophius niloticus*
		Schilbe mystus
		Schilbe uranoscopus
8	Synodontidae	*Synodontis schall*
		Synodontis serratus
9	Mormyridae	*Mormyrus kannume*
		Mormyrus caschive
		Mormyrus anguilloides
		Petrocephalus bane

According to their feeding habits, the fish species in the AHD can classify into four categories (Rashid, 1995):

(a) Periphyton feeders: *Tilapia nilotica* and *Tilapia galilaea*.

(b) Omnivores: *Labeo* spp., *Barbus* spp., *Synodontis* spp., *schilbeides* and *mormyrids*.

(c) Piscivores: *Lates* spp., *Hydrocynus* spp., *Bagrus* spp., *Clarias* spp. and *Heterobranchus* spp.

(d) Plankton feeders: *Alestes* spp.

Although fish may sometime change their feeding habits according to food availability, any change in the food web may trigger major changes in fish population, density of distribution.

Different characteristics of reproduction and spawning behavior of each fish species and their ability to adapt to new created conditions is an important aspect controlling the fish dynamics and species composition. For example, species as *Tilapia nilotica, Tilapia galilea, Hydrocynus forskahlii* and *Alestes nurse* are spawning fractionally in most of the years whereas the other species spawn once

or twice per year (Rashid, 1995). Even characterized by low fecundity and low mortality rate because of the parental care of up to 3 mm in diameter eggs (Latif and Rashid, 1983)[21], the fractional spawner *Tilapia nilotica* is the most predominant species in fish landings in AHD contributing up to 70 % of the catch (Rashid, 1995). Its excellent growth of up to 55 cm, its preference for shallow near-shore waters and mouth-breeding habits have been explained its perfect adaptation. Reaching a large size, *Lates niloticus* is another important contributor to the fish landing in the AHD ensuring his linger by producing several millions pelagic eggs of about 600 µm in diameter (Rashid, 1995).
Spawning of some cyprinids and characins species which live mainly in Lake Nubia (Sudan) is induced by the flood. The fishes move upstream beyond the Second Cataract where the area of the reservoir is much narrower and the early flashes of the flood probably trigger their spawning process (Rashid, 1995).

3.8 Development Potential around Lake Nasser

3.8.1 Introduction

Egypt’s strategy for agricultural development aims at reclaiming about 3.4 million feddans by the year 2017. The Master Land Use Plan of Egypt indicates that there are about 2.88 million feddan reclaimable by the Nile water and 0.55 million feddan reclaimable by ground water. The main reclaimable areas of and around Lake Nasser are located in the East bank of the Lake in Wadi El-Allaqi and Wadi El-Targi. Those in the west bank are found in Wadi Kurker, Kalabsha, Dekka, Marwa, Tushka, Abo-simble, Khor Sara, Tomas and Affia (Desert Research Center, 2005).

As part of the national strategy to combat poverty, the Government of Egypt plans to settle approximately one million people on reclaimed desert in the area around Lake Nasser by the year 2017. Experience in other countries shows that new settlers can be highly vulnerable to hardship and that the impact of new settlements on the environment can be adverse. In order to avoid these negative impacts there are a number of research projects being undertaken to develop sustainable strategies for improving the socioeconomic conditions, health and livelihoods of poor and marginalized settlers living in fragile ecosystems. Researchers work closely with members of the community (men and women) and decision-makers to encourage agro-ecology as an alternative farming system, increase incomes through value-added production and niche marketing, and mitigate environmental threats to human health (El-Fattal, 2005).

[21] Latif F.A. & Rashid M.M. (1983) "Reproduction of *Tilapia nilotica*" Asw.Sci.Tech. Bull. 4: 207-223.

3.8.2 Historical development of the area of and around Lake Nasser (Aswan Province):

(i) Research

In 1963 The Government of Egypt established the Aswan Regional Planning Authority (ARPA) to plan and implement the development of Aswan Governorate following the completion of the High Dam. A research function was added in the mid-1960s based on recommendations from the United Nations Development Program (UNDP). In collaboration with the Food and Agriculture Organization of the United Nations (FAO), UNDP was assisting several African governments to establish research organizations on new man-made lakes. In 1966 UNDP's Governing Council approved a similar request from Egypt to establish a "Lake Nasser Development Centre" which became operational in July 1968 for a six year period.

Development-relevant research activities included agriculture, fisheries, public health, settlement planning, tourism and transportation. A final report was issued in 1975 on project findings and recommendations. Subsequently a High Dam Development Authority (HDDA) was established to develop the lake region. Planning has continued into the present century, with socio-economic plans for the Aswan area and the reservoir being prepared with UNDP assistance during the 2000-2004 period (Scudder, 2003).

(ii) Agriculture and Settlement

Under the UNDP/FAO project, a 60 feddan research station was built near Abu Simbel and several kilometers inland from the reservoir to experiment with different crops in the reservoir drawdown and inland areas. Results suggested that it might even be possible to restore the lucrative cultivation of date palms that provided the principal cash crop before the construction of the original Aswan Dam. Between 1968 and 1974 extensive soil surveys were carried out by government staff using project-supplied aerial photography. Though requiring use of fertilizers, large areas, especially around reservoir inlets, were identified as having agricultural potential. Including areas requiring lift irrigation up to 30 meter above full storage level, it was estimated that 10 percent could be added to Egypt's total arable land.

Below full storage level, approximately 200,000 feddans could be cultivated during the winter months in short maturing crops "using mainly subsoil moisture" though supplementary irrigation would increase reliability of yields (UNDP/FAO 1975). The most economic crops without irrigation would be fodder crops and vegetables along with a wide variety of fruit trees along the reservoir margin.
Further inland in the Tushka depression 500,000 feddans were identified for pump irrigation. Granted the escalating costs of pump irrigation at higher

elevations and the extensive reservoir drawdown during drought years, these figures may be significant over-estimate. Nonetheless, the potential appears to be considerable. In response a majority of Saiidi fishers from overcrowded rural communities have stated a desire to farm such lands with their families if government facilitated their settlement in viable communities in terms of housing, social services and transport.

3.8.3 Potential Reclaimable Areas in the Lake Nasser Area

(i) Around Lake Nasser

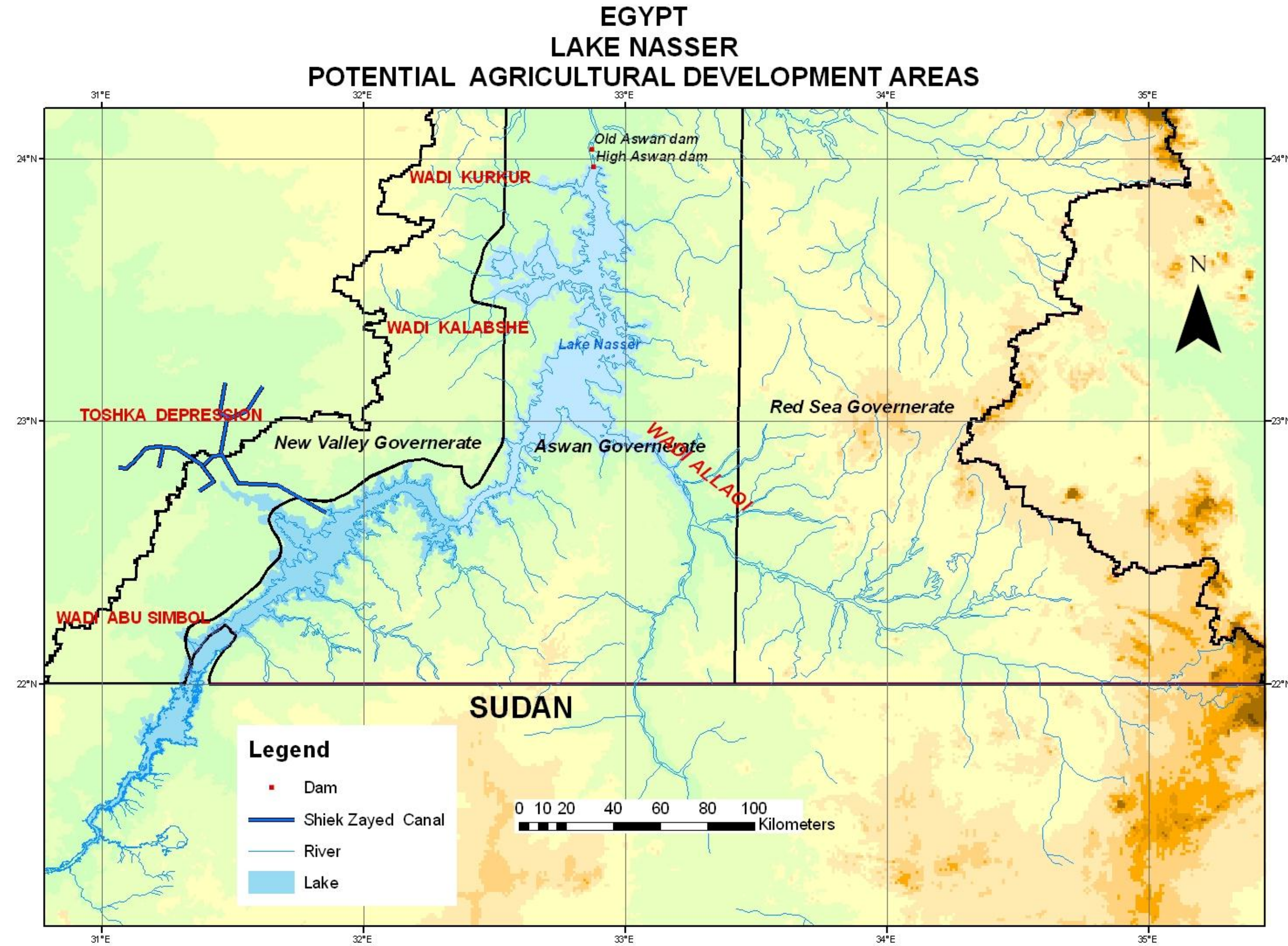
There are a number of estimates regarding the potential for land reclamation around Lake Nasser. Aerial photos show that 1.5 million feddans are reclaimable in the elevated area of and around Lake Nasser (Encyclopedia of Southern valley and Tushka, 1999). Also Hanna and Osman (1993) stated that more than one million feddan can be reclaimed around the reservoir. The Egypt Water Master Plan (1986) however, shows only about 195,000 feddans to be of high priority to be reclaimed out of 781,600 feddans. In 1987, A joint study between Cairo University and MWRI showed that the arable area of and around Lake Nasser is about 103,500 feddans.

The Government plan is to cultivate 50,000 feddan around Lake Nasser's shores. They are situated on the western shore, and only one area of 9,000 feddans on the east side shore, i.e. the Wadi Allaqi area. On the west side the three areas are: Wadi Kurker, 14,000 feddans; Kalabsha, 22,000 feddans; and Abu Simble 5,000 feddans (Map 9).

Studies carried out by the Desert Research Center (DRC, 1999) show that lifting water from Lake Nasser depends on the elevation above sea level (masl). Two methods are used:

(i) Lifting water for high lands (above 182m masl) by using giant pump stations and floating pipe line then connected to affixed pipe line on land.

(ii) Lifting water for Lake Shore farming and irrigation by using small mobile pump motors that the farmer moves from field to another. These pumps are connected to a flexible hose and then to 4-6 aluminum pipes.



Map 9. **Egypt – Lake Nasser: Potential Agricultural Development Areas.**

a. Wadi Kurker:

Location: Located on the West bank at Longitude 32° 20' - 32° 52' E and latitude 23° 28' - 24° 00'N. It covers about 3,000Km^2 (714,000 feddans).

Climate: is hyperthermic and torric.

Soil type: sandy to sandy loam soils, also clay to clay loam soil are found.

Suitability: soils are of second and third productivity classes (according to U.S. soil classification), which are suitable for growing field, vegetable and fruit crops. Organic and mineral fertilizers are a must.
Irrigation: Source of irrigation water is Lake Nasser, lifting of water varies between 10 to 50m. Modern irrigation methods are to be used in coarse-textured soils of the area.

Crop Rotations and Land Use:
40% of the area Date-palms, intercropped with fruit trees.
60% for winter crops: clover, onion, legumes and vegetables. Summer crops include sesame, peanuts and millets.
Water requirements are about 12,800m^3/fed./year.

Coarse-textured soils; four-year rotation:

Winter crops include. 25% clover, 25% lentil, 25% faba bean, 25% pea nuts.
Summer crops: 25% sesame, 25% yellow corn, 25% millet, 25% pea nuts.

Water Requirements are about 8,000m^3/fed./year.

b. Wadi Kalabsha:

Location: located on the west bank at longitude 32° 10' - 32° 50'E and latitude 23° 10' -23° 40' south of Wadi Kurker. The total area is about 400km^2 (95200 feddan). The area under reclamation is around 22,000 feddans.

Climate: hyperthermic and torric, except for cool winter months.

Soil Type: includes 3 different types, they are:
Sandy to sandy loam with deep profile.
Sandy to sandy loam with moderate profile.
Sandy loam or loamy sand to clay-loam-sand soils with deep profile.

Suitability: Wadi Kalabsha soils are of the third and fourth classes (U.S. soil productivity classification, 1975). It is suitable to grow field, vegetable and some fruit crops such as olive and date-palm under organic and mineral fertilization. The fifth land class only shallow-root crops can be grown.

Irrigation: as in Wadi Kurker.

Crop Rotations and Land Use: As in Wadi Kurker.

C. Wadi Abu-Simble:

Location: located on the west bank about 250km south of Aswan City at longitude 31° 30' - 32° 05' E and latitude 22° 50' - 23° 30'. It covers an area of about 2,950km^2 (193,4000 feddans). The area under reclamation is 5,000 feddans.

Climate: hyperthermic and torric, cool during December-January.

Soil Type: it is leveled- to undulated surface. Two types are dominant, they are:
Sandy to sand loam clay with a shallow profile.
Sandy loam to loamy sand with a deep profile.

Suitability: Abu-Simble soils are of the second and third productivity classes. It is suitable for growing field crops, date-palm and olives. Shallow-profile soils can be planted by shallow root plants.

Irrigation: As in Wadi Kurker.

Crop Rotations and Land Use: As in Wadi Kurker.

d. Wadi El-Allaqi:

Location: located on the east bank of Lake Nasser at longitude 32° 30' - 32° 45' E and 23° 5' – 23° 18' N. The Wadi covers an area of about 420km2 (100,000 feddan). Only 9'000 feddans to be reclaimed by the year 2017.

Climate: hyperthermic and torric.
Soil Type: Deep-soil sandy to sandy loam, has some gravels.

Suitability: These soils are of the third, fourth and fifth productivity classes. It is suitable to grow field and horticultural crops.

Irrigation: As in Wadi Kurker.

Crop Rotations and Land Use: As in Wadi Kurker.

3.8.2 The Tushka Depression

(i) The Tushka Spillway Project

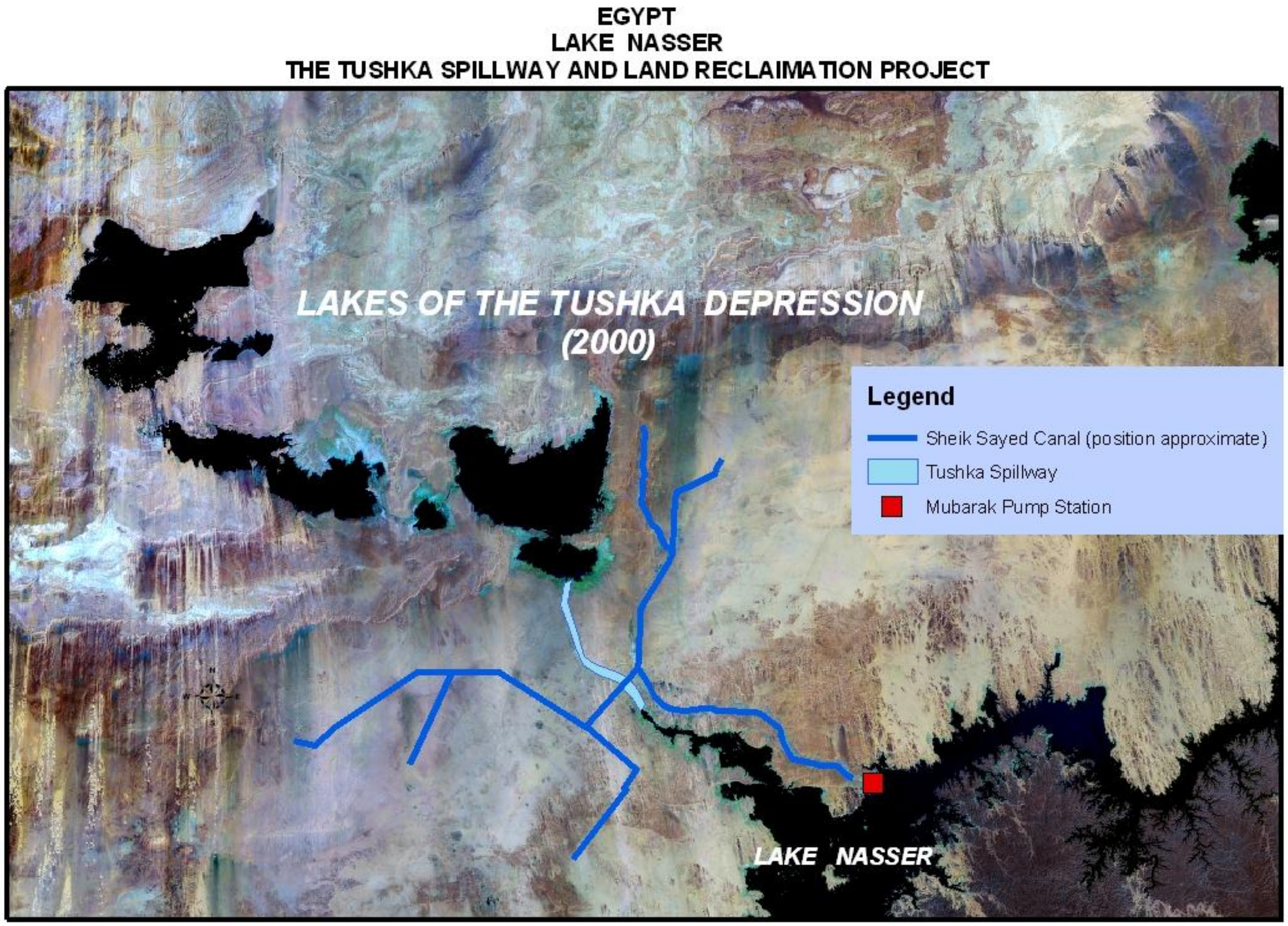
According to instruction of operation for the High Dam issued by “Hydro-project institute Moscow 1970” to protect the AHD and the Nile course downstream Aswan against degradation, the flood control capacity must be emptied down to level 175m before the arrival of the following flood. In certain cases if this was implemented it could result in releasing high discharges that may reach 350-360 million m^3/day (the maximum irrigation requirements is 250 million m^3/day).

Such high discharges would affect the river bed, downstream, control structures on the river, canal intakes and water pumping stations etc. To avoid this it was decided to make use of one of the western valleys (Khor Tushka), connecting a huge depression (Tushka depression) on the western desert to act as additional spillway.

The Tushka Spillway Project included:

- Digging the Tushka Canal, 22km length, to connect Nasser Lake to Tushka depression.
- Excavating the canal inlet as a free spillway at elevation 178masl with a width of 750m located at 250km south of the High Dam on the west side of the reservoir.
- Constructing an Outlet Ogee type weir at the connection of the canal with Tushka depression,
- The maximum potential discharge of the Tushka canal is 250 million m^3/day at elevation 182.7masl.

The project was executed during 1978-1982. The total cost of the project was L.E. 46.6 million.



Map 10. The Tushka Depression, Spillway, Sheik Zayed Canal and Ephemeral Lakes after the 1999 Spill. (Landsat TM Image 2000)

The Tushka spillway has played an important part in flood control and management, during 1998 and 1999 high floods (Map 10). In 1998 the total discharges passed through it were 12.4km^3 and during the 1999 flood passed about 16 km^3.

(ii) Tushka Plain Reclamation Project

The Tushka Project is one of Egypt's mega projects, which is currently under construction with the strong support of President Mubarak. Rather than only using the Tushka depression for drawing off excessive floodwaters from Lake Nubia, the goal of the Tushka Project is to use water pumped from the reservoir to irrigate hundreds of thousands of feddans and to resettle in the Tushka project two million Egyptians from the Nile Valley.

There are a number of components of the Project[22]. The Mubarak Pump station has an intake channel 4.5kms long, of which 3kms is underwater. The station itself has 24 centrifugal pumps that can pump from 147 to 182masl to delver to the Sheik Zayed Canal at 201masl. The Main Canal is 50.8kms long, with a bed width of 30meters, a top width of 58 meters, a water depth of 6 meters and freeboard of 1 meter. The Main Canal has a Control Regulator at km30. A distribution regulator at km50.8 divides the flow into two branches: one north and the other south. The south branch is siphoned underneath the Tushka Spillway. The branches in turn divide into Sub-canals 1 and 2, and 3 and 4.

Sub-canals 1 and 2 will serve 120,000 feddans each under the management of the Kadco and South Valley Companies respectively Sub-canal 3 serving 100,000feddans is being financed by the Abu Dubai Fund whilst Sub-canal 4 serving 200,000 feddans is dedicated to an Egyptian Company. Thus, there is potentially a total area of 540,000 feddans (226,800ha) that can be irrigated.

All canals are lined and the main regulators are linked electronically. The most modern methods of irrigation will ensure water use efficiency. Surface water will be supplemented by groundwater from a number of productive wells (currently 85). The wells will eventually irrigate 60,000feddans. There will be strict controls on the use of agro-chemicals.

The water requirement for the area has been estimated at 5km3 for the first stage of cultivating 500,000feddans. Water for the project will be obtained from saving in current water use by limiting the area under rice and sugar cane, converting to drip and sprinkler irrigation systems, re-use of drainage water and savings in eliminating wastage from domestic use.

[22] MWRI & South Valley Dev. Project (2006) "Toshka Project: Towards a Better Future", April, 2006.

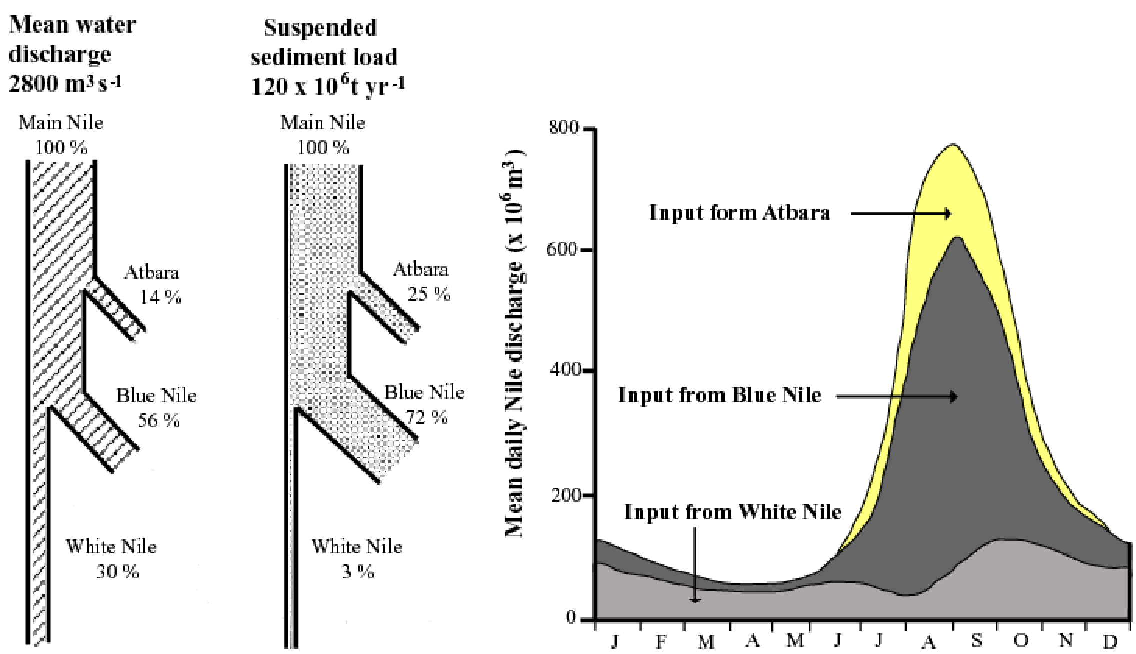
4. PROBLEM-SOLUTION ANALYSIS

4.1 Assessment of the Origins, Extent, Trends and Impacts of Upstream Sedimentation in Lake Nasser/Nubia

4.1.1 Origins and Rates of Sedimentation

The suspended sediment load entering Lake Nasser/Nubia is almost entirely from the Ethiopian Highlands (Figure 3). Some 97percent is derived from the Blue Nile (72%) and the remainder from the Atbara (25%). The mean water discharge differs considerably with the White Nile contributing 30percent and the Blue Nile and the Atbara 72 and 25pecent respectively.

Figure 3. Mean Discharge and Suspended Sediment Load for the Nile Basin.



The concentration of suspend sediment entering Aswan High Dam Reservoir also has a seasonal variation similar to the flow hydrograph. However, the peak discharge and peak suspended sediment concentration do not occur simultaneously. The suspended sediment concentration rises to a maximum (5,000 ppm) many days before the peak of water discharge. The lag time between the peak of the water discharge and the suspended sediment concentration varies from year to year, and on average is approximately 10 days.

Shalash (1980)[23] estimated an average annual rate (1958-1979) of sediment inflow of 130million tons, outflow of 6million tons and a net sedimentation rate within the reservoir of 124million tons. Although in a second paper Shalash (1982)[24] estimated the total annual inflow as 142million tons, the average rate of outflow as 6million tons with a net sedimentation within the Lake of 136million tons. Using an average sediment density of 1.56 g cm^{-3} and corrected for compaction (dry weight density of 2.6 g cm^{-3} and a porosity of 40 %), the amount of annually retained sediment of 136million tons of suspended sediment corresponds to an accumulated volume of 87million m^3 per yr (Shalash, 1982).

El-Moattessem and Makary (1988)[25] using sediment and discharge data from Dongola (Sudan) from May 1964 to December 1985, estimated the total volume deposited within the Lake as 1,657 million m3 or 75million m^3 per yr. Using the Shalash conversion factor this is equivalent to 117.2million tons per yr. The calculated volume for the same period from the hydrographic survey was 1,647million m^3 very close to the estimated figure. At this rate the dead storage capacity of 31.6km3 would be lost in 420 years (close to the design life of 450 years).

El-Manadely (1991) and Abdel-Aziz (1991) used a one dimensional model and estimated the total volume of deposits in the reservoir between 1964 to1988 at 2,650million m^3 or 106million m3 per year. Dead storage would be lost in 300 years at this rate of sedimentation.

Based on sedimentation data over a 5 years study interval between 1987 and 1992 by Eldardir (1994[26]) a sediment volume of 119million m^3 per yr was estimated to be annually deposited in the AHD Reservoir. This is equivalent (using Shalash's conversion factors) to 186million tons per year (for the study period). This result implies that after the 41 years since the AHD closure in 1964, the reservoir has lost ~ 11 % of its dead storage capacity (~ 0.3 % annually). At this accumulation rate the dead storage capacity in 360 years.

However, it is important to note that there is considerable annual variation in sediment load, ranging from 50 and 228million tons.

[23] Shalash, S (1980) "Effect of sedimentation in Aswan High Dam reservoir", Nile Research Institute, Cairo, Egypt.

[24] Shalash, S. (1982) " Shalash S (1982) Effects of sedimentation on the storage capacity of the Aswan High Dam reservoir. Hydrobiologia 92: 623-639.

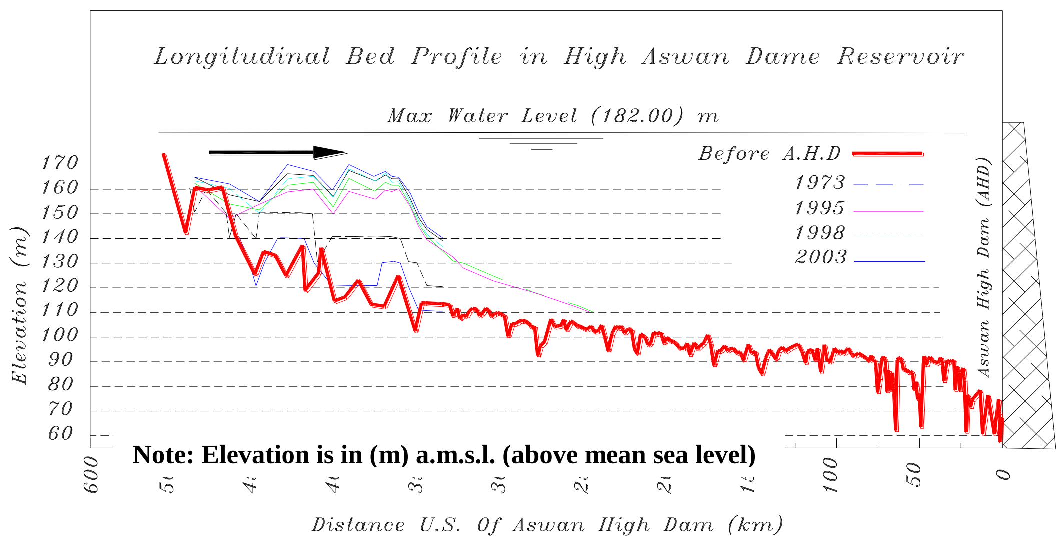
[25] El-Moattessem M. & Abdel-Aziz, T.M. (1988) "A Study of the Characteristics of Sediment Transport in the Aswan High Dam Reservoir", report No. 117, Cairo, Egypt.

[26] Eldaardir, M (1994) "Sedimentation in the Nile High Dam Reservoir: 1987 – 1992, and Sedimentary Futurologic Aspects", Sediment Egypt 2, 23-39.

4.1.2 Spatial and Volumetric Extent of Sedimentation

The extent of the sediment has been measured by Mohamed El-Moattassem et al, 2005). The sediment deposition is concentrated at the head of the Lake mainly in the Sudan. Figure 4 describes the longitudinal section of the lowest bed elevation of Aswan High Dam Reservoir (AHDR) from year 1964 to 2003.

Figure 4: Longitudinal bed elevation profile for Aswan High Dam Reservoir (Source: Mohamed El-Moattassem et al (2005)



Since 1973 cross-section measurements have been taken at selected points the follow changes in the lake bed. By 1973 about 20 meters of sediment had been deposited near the Second Cataract (345-370kms upstream from the Aswan High Dam). From Km 345 to km 285 the deposits decreased to less than 1 meter forming an inland delta some 85kms long. By 2000 the maximum deposits had reached 60 meters near the Second Cataract and deposition of sediment now reached 120kms from the dam. Thus, the inland delta had extended some 165kms and now stretched 250kms.

4.1.3 Future Trends under Present Sedimentation Rates

The model was run using a time series of seven flood years (2003-2010) followed by five low flood years (2011 – 2015). For the seven high flood years, the whole bed level will raise by approximately 3.5 to 1.5 m in the inlet zone (i.e. from km 500 till km 370 upstream AHD), and by 1.5 to 0 m in the rest of AHDR.

During the successive five low flood years, the bed level is predicted to increase by a value between 2.5 and 2.0 m at the inlet zone and by 2.0 to 0 m in the rest of AHDR.

4.1.4 Impacts of Current and Potential Dam Construction in the Eastern Nile Basin

The modeling assumed that the sediment load would remain constant in the future. In fact there are a number of on-going and potential developments that could significantly alter this assumption. There are currently three on-going dam construction projects being implemented: one on the main Tekezi River (Tk5) in Ethiopia, a second on the Beles River (a tributary of the Abay River) also in Ethiopia, and a third on the Main Nile (Meroe) in the Sudan. A fourth development that could also affect the sediment load reaching Lake Nasser is the on-going soil and water conservation programme in Ethiopia that contains a significant small and micro dam component.

The suspended sediment load at the site of the Tekezi dam is estimated to be 31.1million tons/yr. It has not been possible to determine the trapping efficiency and what if any, the flushing regime will be. As the dam is for hydro-power generation the aim will be to keep this to a minimum and substantial sedimentation can be expected. The consultants' report (Tekezi Medium Hydro-Power Project) assumed a dam-storage of 4.54 billion m^3 and a trapping efficiency of 100 percent to determine the economic life of the dam. Assuming that a "flushing" regime similar to Roseires, Sennar and Kashm el-Girba is practiced the trapping rate could be reduced to 30 percent, thus reducing the annual suspended sediment load from 31.1 million tons to 9.33million tons per year.

The suspended sediment load on the Beles River is estimated to be 1.56million tons/yr. The dam is for power generation and irrigation. Assuming a 100 and 30 percent trapping rate the sediment reduction would amount to 1.56million tons and 0.468million tons per year respectively.

The Meroe Dam is a very substantial structure with a storage capacity of 8.3billion m^3. As the dam is below the confluence of the Atbara all sedimentation studies have assumed a suspended sediment load at the site as that at Dongola (about 142million tons/yr). The dam is fitted with deep sluices and these could be used to operate the dam at a relatively low level during the period of highest sediment concentration. Whilst reducing power output it would reduce sedimentation within the dam.

Exactly how much sediment will be retained by the dam is a matter of some controversy. Three studies are available: (i) by Lahmeyer International[27], the supervising consultants, (ii) a study by MIT[28], and (iii) by the EAWAG, Switzerland[29].

The Lahmeyer study estimates that some 30percent of the annual mean sediment load of 120million tons will be retained within the reservoir behind the dam.

The EAWAG study disputes this and claims some 90percent of the annual sediment load will be retained behind the dam. This study also uses an estimated mean annual sediment load of 143million tons. The study estimated that the reservoir would fill completely in approximately 150 years.

The MIT study estimates a trapping percent of 84percent of which 65percent will rest in the dead storage and 35percent in the live storage. It used a mean annual sediment load of 128million tons but notes that this can vary from 50 to 228million tons. The MIT study looked at the changes in trapping efficiency as the reservoir capacity decreased. It also assumed that the dam would be operated to allow at least 40percent of the sediment to pass through the sluices in July-August with a net retention rate of 60percent. It looked at six scenarios of varying flow rates and sediment loads to determine the economic life. Assuming 60percent retention and a suspended load of 128millions tons it estimated the economic life of the dam as 105 years.

It is not possible to estimate with certainty what the impact on suspended sediment loads of the Atbara and Blue Nile a major soil and water conservation and small dam programme will be. It has been estimated (Tekezi Medium Hydro-power Study) that 20 micro dams will reduce run-off between 80million and 200million M3/yr. Assuming 1ton of suspended sediment for 440million m3, a 100 micro dams could reduce total suspended sediment load by 0.5 to 1.3million tons/yr.

There are a number of other potential large dams in the Eastern Nile basin that are now being seriously considered that will also have substantial impacts on suspended sediment loads downstream. The largest of these is the Karadobi Dam on the Abay within in Ethiopia. The Pre-feasibility Study[30] estimates the trapping efficiency of 86.5percent over a 50 years period and trapping between

[27] Lahmeyer International (2001) "Meroe dam Project: Project Assessment Report", for MIWR, Khartoum.
[28] Paris, A, T.Yamana and S.Young, (2004), "Sustainability Considerations in the Design of Big Dams: Merowe, Nile Basin", May 19, 2004.
[29] C. Teodoru, A.Wuest & B.Werhli, (2006) "Independent review of the Environmental Impact Assessment for the Merowe Dam project, Nile River, Sudan.", March 15, 20056.
[30] Norplan-Norconsult-Laymeyer (2006) Pre-feasibility Study of the Karadobi Multi Purpose Project", for Ethiopian MWR, May 2006.

60.5 and 99.4 million tons a year. Thus the suspended sediment of the Abay/Blue Nile would be reduced to between 9.4 and 15.5 million tons per year.

A second example is that of the proposed Baro 1 and 2 Multi Purpose Dams on the Baro River, the main tributary of the Sobat. Current suspended sediment load at the dam site is estimated to be 0.415 million tons per year. To simulate forest removal an increased sediment load of 1.339 million tons per year was used. A trapping efficiency of 100percent was assumed in the calculations of the life of the dead storage.

It is clear that even with the current dam building programme there are likely to be substantial reductions in suspended sediment entering Lake Nasser in the future.

Table 15a. Egypt – Lake Nasser: Estimated Suspended Sediment Retention in Reservoirs of Dams Currently Under Construction and of Proposed Dams in Ethiopia and Sudan.

Dam	Low sediment retention (million tons/yr)	High sediment retention (million tons/yr)
A. UNDER CONSTRUCTION		
Tekeze (Atbara)	9.33	31.10
Tana-Beles (Blue Nile)	0.47	1.56
Micro dams – Ethiopia	0.50	1.30
Meroe (Main Nile)	33.00 [1]	97.24
Total	**43.30**	**131.16**
B. PROPOSED		
Karadobi	60.50	99.40
Baro 1	0.42	1.34
Total	**60.92**	**100.74**

1. Assumes 120 million tons + reduced sediment load at Meroe due to reductions in Ethiopia (109.7million tons)
2. Assumes 142 million tons + reduced sediment load due to reductions in Ethiopia (108.04million tons)

Table 15b. Egypt – Lake Nasser: Estimated Net Suspended Sediment Reaching Lake Nasser/Nubia after Retention in Reservoirs of Dams Currently Under Construction and Proposed Dams in Ethiopia and Sudan.

	Low sediment retention (million tons/yr)	High sediment retention (million tons/yr)
Dams Under Construction	76.70	10.8
Plus proposed Dams	36.26	7.30

Assuming a current mean annual sediment load of 142million tons entering Lake Nasser/Nubia, sediment rates could reduce by between 25 and 91 percent with current dam construction in the East Nile Basin. With the Karadobi and Baro 1 dams this reduction could rise to between 74 and 95 percent.

Clearly, this takes no account of the certain degradation of river beds and increased bank erosion that will occur because of the increased energy of the Main Nile, Blue Nile and Atbara Rivers within Sudan. This will certainly provide an increased contribution to suspended and bed load sediment. In addition, there is a potential problem of sediment in the delta at the entrance to Lake Nubia being eroded and carried further into the Lake towards the dam wall.

4.2 Environmental and Hydrological Impacts of Impoundment of Water in Lake Nasser

4.2.1 Reservoir Induced Seismicity

On 14 November 1981, six years after the AHD Reservoir reached its maximum level of 72 m (1975), a first earthquake occurred near the edge of the lake, about 65 km to the south-west of the dam on the Kalabsha fault at a depth of about 20 km (Kebeasy et al., 1991; Abu-Zeid et al., 1995)[31] [32]. With 5.5 degree on the Richter scale, the local magnitude was felt as far as 900 km south at Khartoum and causing some damage at Aswan. As the event occurred at a significant distance from the reservoir and at considerable time after impounding (16 years), it was not clear whether it was a reservoir-induced earthquake.

Subject of many studies, the reservoir behind the AHD was considered not to contribute to seismic activity as the depth of seismicity was larger than 15 km and the penetration of water to affect water pressure at this depth was hypothetical (Meade, 1991)[33]. However, the theory of induced earthquake mechanisms of Simpson (1976)[34] suggests that the first event should appear at some distance from the deepest part of the reservoir and may occur some time after impounding when the effects of increased pore-pressure overcome the effect of loading. Also, the existence of long-continuity aftershock sequence as in the case of Lake Nasser with a frequency of 0 to 10 events per month between

[31] Kebeasy, R.M. et al (1991) "Aswan Lake Induced Earthquakes.", Bull. Intern. Inst. Seism. Earthq. Engin., 19, 155-160.
[32] Abu Zeid, M. et al (1995) "Seismicity induced by Reservoir: Aswan High Dam", Water Resources Development, 11: 205-213.
[33] Meade, R.B. (1991) "Reservoirs and Earthquakes", Engineering geology 30: 245-262.
[34] Simpson, D.W. (1976) "seismicity changes associated with reservoir loading", Engineering geology 10: 123-150.

1982 and 1998 was considered a feature of reservoir-induced seismicity (Selim et al., 2002)[35].

The statistical investigation of reservoir-induced seismicity in AHD has shown a strong correlation with the water level fluctuations. The seismicity was observed active during periods of decreasing water levels (Selim et al., 2002). These correlations supported the conclusion of reservoir-induced seismicity at AHD.

However, a safety analysis by Cluff and Cluff (1990)[36] concluded that it was not necessary to regulate the water levels behind the dam for seismic considerations.

4.2.2 Water Losses

Omar and El-Bakry (1981)[37] estimated the monthly evaporation values of the Lake behind the Aswan High dam by the heat budget and bulk aerodynamic methods using monthly estimates of different meteorological elements over the lake based on measurements taken during trips over the Lake at different months in 1970-71. Monthly evaporation was calculated as the average of estimates by both methods. Annual Lake evaporation was found to be about 7.4 mm per day with maximum evaporation in June (10.9mm per day) and minimum in January (3.8mm per day). The total annual water loss by evaporation was estimated to be 14km3 or about 11 percent of the Lake water at 175masl.

The evaporation from the Lake based on isotope analyses was estimated to vary between 18 and 21 % (19 % in average) of the total river input (Aly et al., 1993)[38]. A later review of previous literature data established a larger range for evaporation from Lake Nasser between 1.7 m yr^{-1} and 2.9 m yr^{-1} (Sadek et al., 1997)[39]. Based on water balance, energy budget and modeling techniques, a narrower range of 2.1 m yr^{-1} to 2.6 m yr^{-1}, with an average of 2.35 m yr^{-1} was calculated by Sadek et al., (1997).

[35] Selim M.M. et al (2002) "Statistical investigation of reservoir-induced seismicity in the Aswan area, Egypt", Earth Planets Space 54: 349-356.
[36] Cluff, L.S. & J.L.Cluff (1990) " Seismic safety of the Aswan High Dam, Egypt", quoted in Abu-Zeid, M et al "Seismicity Induced by Reservoirs", in Eds. Mahmoud A. Abu-Zeid & Asit Biswas "River Basin Planning and Management", OUP.
[37] Omar, M.H. & M.M. El-Bakry (1981) "Estimation of evaporation from the lake of the Aswan High Dam (Lake Nasser) based on measurements over the lake" Agricultural meteorology 23: 293-308.
[38] Aly A.I.M. et al (1993) "Study of Environmental Isotope Distribution in the Aswan High Dam Lake (Egypt) for Estimation of Evaporation of Lake water and its Recharge to Adjacent Groundwater", Environmental Chemistry and Health 15: 37-49.
[39] Sadek M.F. et al (1997) "Evaporation from the reservoir of the High Aswan Dam, Egypt. A new comparison of relevant methods with limited data", Theoretical and Applied Climatology 56: 57-66.

In a 2002 technical report, based on the available data at the Nile Forecasting Center in Cairo, it was estimated that the annual evaporation from the AHD Reservoir varied between 12 and 12.6 km^3 per year which correspond to an evaporation rate of 2.0 to 2.1 m yr^{-1} (Roskar, 2000)[40]. Compared to the reservoir volume of 162 km^3, the evaporation represents about 8 % per year but more than 15 % of the river inflow of 84 km^3 yr^{-1}.

In addition to the water loss via evaporation, the seepage of the AHD to the lateral groundwater aquifers was calculated to reach 1 km^3 yr^{-1} representing 1.2 % of the river inflow (Aly et al., 1993).

Jeongkon Kim and Mohamed Sultan (2002)[41] used a calibrated groundwater flow model to investigate the long-term hydrological impacts of Lake Nasser and also the proposed large scale irrigation development in the Tushka Depression. Simulations of long-term effects (30 years beyond 2000) of lake Nasser on re-charge and temporal groundwater head showed that recharge from the lake will continue at a much slower rate than the previous 30 years – with an approximately 86 percent reduction in 30 year re-charge. The projected pumping from the lake was not expected to cause a major deviation in the overall head distribution. However, investigation of the effects of the new irrigation development on the Nubian Aquifer indicated that many of the proposed irrigation areas, especially those with small aquifer thickness, will become fully saturated with introduced drainage water, resulting in flooding and salinization.

Predictive analysis from an ongoing study of the groundwater situation of Lake Nasser suggests that impedance of silting in the Lake and the gradually decreasing difference between lake stage and near-lake heads are causing a general rise in Lake Nasser surface water level and a decrease in groundwater re-charge rates from the lake with time[42]. The analysis is the result of preliminary groundwater models for the south-western corner of the lake.

[40] Roskar J (2000) "Assessing the water resources potential of the Nile River based on data available at the Nile Forecasting Centre in Cairo", Hydro-meteorological Institute of Slovenia UDC: 556.53 (Ljubliyana).
[41] Jeongkon Kim & Mohamed Sultan (2002) "Assessment of the Long-term hydrological impacts of Lake Nasser and related irrigation projects in South-western Egypt", J. of Hydrology 262, Issues 1-4, 68-83.
[42] Western Michigan University/MoWRI (2006) “Towards a better understanding of the hydrology of lake Nasser, Egypt”, Web site: Earth Sciences and Remote Sensing, Western Michigan University, USA.

4.2.3 Water Quality

(i) Thermal Stratification

A general effect of water storage due to river impoundment in arid and semi-arid areas is the onset of thermal stratification of the water column. Surface temperatures of 27 to 30 °C were measured in Lake Nasser from May to August 1976 and 1977 whereas temperatures of 20 to 22 °C were recorded at 16 m depth (Rashid, 1995)[43]. During November to February 1976 and 1977, no differences in temperature were observed between the surface and deep water.

The AHD Reservoir exhibits a distinct stratification pattern which varies from the main channel to the flooded side bays. Measurements in the AHD Reservoir showed that the thermal stratification of the water column starts usually in May extending from north to south to almost the entire water body. At the beginning of the flood period in late July, the thermal stratification is usually vanished in the southern reaches of the reservoir whereas the northern sectors remain stratified until late October when the seasonal cooling leads to deep convective mixing (Abu-Zeid, 1987)[44].

(ii) Dissolved Oxygen

Dissolved oxygen concentration in the water column reflects closely the main phases of thermal stratification. The oxygen profile decreases with depth. For example, from March to June 1976/1977, dissolved oxygen concentrations above 8.5 mg/l (with high values up to 14 mg/l near the surface) characterized the uppermost 10 m of the northern sector of AHD but were as low as 2 mg/l near the bottom (Abu-Zeid, 1987; Rashid, 1995). In July/August, the dissolved oxygen concentration ranged between 9.8 to 0.0 mg/l in the upper 15 m.

A stable stratification of the lake water column was therefore, evident with an oxygen minimum between 10 and 25 m. During 1978 an oxygenated layer was limited to the top 10 m in July and August for the northern AHD whereas in October-November, stratification started disappearing with the oxic layer extending to 40-50 m below surface (Abu-Zaid, 1987). In December, the lake water becomes usually saturated or near-saturated with oxygen from the surface down to the bottom (Rashid 1995).

Also, in the northern part of Lake Nubia, dissolved oxygen was absent near the bottom during August 1976 in the side bay whereas in the riverine section of the lake, the concentration was about 8 mg/l all the time (Rashid, 1995). In Lake Nasser (Egypt) oxygen-free conditions at the reservoir bottom were extending

[43] Rashid, M.M. (1995) op. cite
[44] Abu Zeid M.(1987) op. cite

progressively towards the dam over a general stratification period of between 5 and 8 months (Entz, 1980)[45]. The flood affected the stratification only in the southern part of the lake and therefore, the mixing process was often incomplete (Rashid, 1995).

Measurements of dissolved oxygen in the water column along the main body of AHD during 1982 and 1984 revealed a wide spatial and seasonal variation in concentrations (Ahmed et al., 1989[46]; Mohammed at al., 1989[47]). At 10 km south of the dam the values ranged from a minimum of 4.3 mg/l in autumn 1982 to a maximum of 9.0 mg/l in winter 1982. At 245 km south of the dam, the highest values of 8.1 were recorded in the summer 1982 and 1983 respectively (Figure 4). The saturation of water with oxygen in the AHD was associated with the high level of algal photosynthetic activity (Mohammed et al., 1989). The vertical distribution at 10 km south of the AHD showed oxygen super-saturation only in April and June 1982 and May 1983 at times of intensive phytoplankton development (Ahmed et al., 1989). The oxygen saturation in the reservoir remained below saturation in 1982 and 1984 with a lowest level of 28 % during summer when the thermal stratification was well established (Mohammed et al., 1989).

(iii) Salinity

Salinity, defined as the total content of all dissolved ions per volume of water, is controlled by the net accumulation of salt from all sources minus the losses through outflow and mineral precipitation. Several indications of an increased salt content of the Nile water between Aswan and Cairo were observed during 1963-1971 after closing the AHD (Hilal and Rasheed, 1976)[48].

The longitudinal series and an earlier comparison of seasonal changes at Aswan and Cairo showed that the observed increase in salt content was mainly attributed to increases in the ions Na^+ and Cl^-. Conductivity values in Lake Nasser were higher than expected form the simple seasonal mixture of Blue and White Nile water (Talling, 1980)[49].

Monitoring of Lake Nubia has shown a gradual annual increase in average total dissolved solids concentration from: 153 mg/l in 1978 to 156 mg/l in 1979, 158

[45] Entz, B.A.G. (1980) op cite
[46] Ahmed, A.M. et al (1989) op. cite.
[47] Mohammed A.A. et al (1989) op. cite.

[48] Hilal M.H. & Rasheed M.A. (1976) "Some chemical changes in properties of the Nile water after construction of the Aswan High Dam", J. of Soil Science 16: 1- 8.
[49] Talling, J.F. (1980) "Some problems of aquatic environments in Egypt from general viewpoint of Nile ecology", Water Supply and Management 4: 13-20.

mg/l in 1980, 162 mg/l in 1981 and 163 mg/l in 1982 (ILEC, 2005)[50]. About 30 % higher values were measured during the dry season months compared to the flooding and after-flooding season. This was explained by the increased contribution of the White Nile water with relative higher total dissolved solids compared to the Blue Nile and the dilution effect during the flood periods. However, the linear increase in total dissolved concentration between 1978 and 1982 was attributed to the water losses by evaporation.

Water quality measurements at the AHD indicate that the salinity varies from 5 to 20 %, depending on the reservoir surface and the seasons (Abu-Zeid, 1987). A salt balance model based on measurements since 1913 showed that the evaporation in the Aswan Reservoir resulted in a 10-15 % increase in total dissolved solids of the water released from the dam (Abu-Zeid, 1987). This increase in salt content per se is currently not a serious concern – more critical is the loss of water.

4.2.4 Bio-chemical Cycling

(i) Nitrogen

The nutrient concentrations in AHD were reported to be higher in the southern part of the reservoir. Ahmed et al., (1989)[51] found a general decrease of NO_3 – N concentration towards the dam (Figure 5) when studying the Lake Nasser between 1982 and 1994. Exceptions form this trend were recorded during the summer 1982/1983 when high values up to 400 µg NO_3 /l were measured 100 km south of the dam (Figure 5). On the South-North transect, the average concentrations were 61, 136, 284 and 289 µg NO_3 /l for spring, summer, autumn and winter 1982, respectively whereas 261 and 286 µg NO_3 /l respectively, were measured during the summer and winter 1983.

The vertical distribution at a sampling site 10 km in front of the dam showed low nitrogen concentrations for early spring and late summer. The lowest value of 2 µg N /l and 8 µg N /l was observed in September 1982 in the surface layers. The reduction of N concentrations in the trophogenic zone down to 8 m in August and September 1982 was attributed to high rates of phytoplankton growth (Ahmed et al., 1989; Mohammed et al., 1989, Figure 6).

A close correlation between nitrate concentration and chlorophyll was found by Mohammed et al. (1989) (Figure 6). Low N-concentrations were postulated to limit the primary production for at least some algal genera or species.

[50] ILEC (2005) "Promoting Sustainable Management of the World's Lakes and Reservoirs. World Lakes Database", http://www.ilec.or.jp/eg/index.html.
[51] Ahmed A.M. et al (1989) op. cite

A similar drop of nitrate-nitrogen down to 20 µg N l^{-1} limiting the growth of algae species was also reported for the Blue Nile during the maximum growth of the diatom Melosira (Rozoska and Talling, 1966).

Figure 5. Seasonal local variations in nitrate - nitrogen concentration in Lake Nasser (Egypt) from spring 1982 to winter 1983/1984 (after Ahmed et al., 1989)

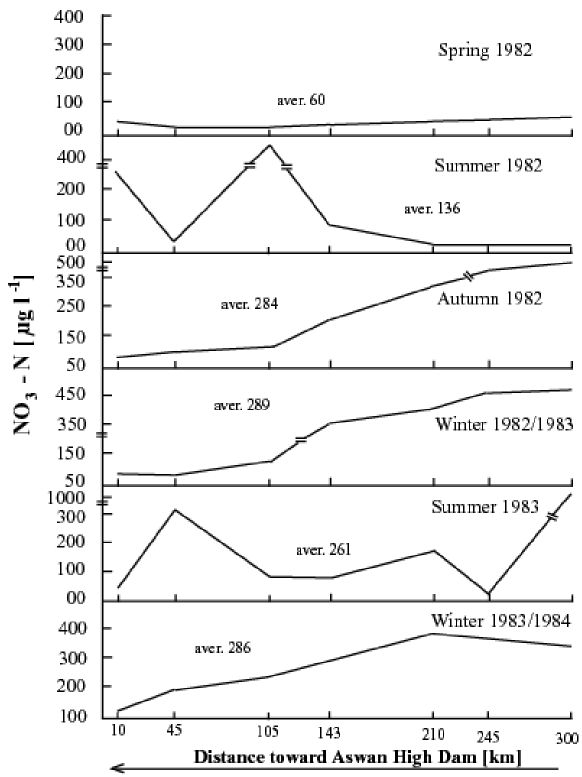
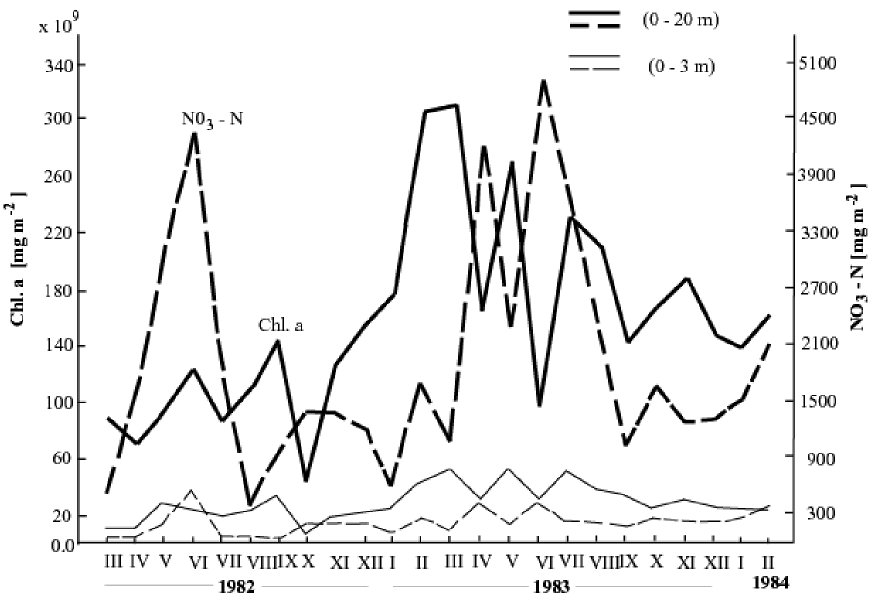


Figure 6. Depth-time distribution of NO_3-N and chlorophyll a concentration integrated over the water column down to a depth of 3 and 20 m in AHD at a station 10 km south of the dam (after Mohammed et al., 1989).



The data allows only some tentative scenarios of nitrogen uptake and release[52]. If it is assumed that the decrease from 500 to about 60 µg N l^{-1} observed during the winters 1982/1983 and 1983/1984 (Figure 5) in the S-N transect in Lake Nasser (km 245 - km 10) was due to nitrogen uptake by mainly by phytoplankton and macrophytes, the annual biological nitrogen consumption in Lake Nasser would correspond to about 71,000 t N /yr. With a molar ratio of 106 C:16 N, the equivalent primary production rate required to fix annually 71,000 t N /yr is 67 g C /m^2 /yr. This rate is found to be much lower than a minimum of 270 g C /m^2 /yr characterizing the eutrophic systems. Also, if the concentration increase along the flow path by about 440 µg N l^{-1} in summer 1982 by 220 µg N l^{-1} one year later (Figure 5) was due to the mineralization of the organic matter, an average mineralization flux of 50,000 t N yr^{-1} or 70 % of the total nitrogen consumption could be estimated. In summary, the observed nitrogen dynamics points to a rather low primary production.

(ii) Phosphorus

In general the PO_4 concentration has been described as having a spatial and temporal variability with higher concentrations of between 120 and 160 µg P l^{-1} reported for the southern part of the reservoir compared to 30 and 160 µg P l^{-1} for the northern part of the Lake (Rashid, 1995). The values were highest in August

[52] Teopdoru, C et al (2006) "Independent Review of the Environmental Impact Assessment of the Meroe dam project (Nile River, Sudan), EAWAG, Switzerland.

and November and lowest in February and increased with depth (Rashid, 1995). In February 1970, measurements in the Lake at a site close to the AHD showed PO_4 values fluctuating between a minimum of 10 µg Pl^{-1} at 50 m depth, and a maximum of 90 µg P l^{-1} at 10 m (Saad, 1980).

Total phosphorus profiles also showed considerable irregular variations between 60 µg P l^{-1} and 175 µg P l^{-1} (Saad, 1980). In general, the values of reactive phosphate found in most samples of Lake Nasser were much lower than those of non-reactive phosphate illustrating a mineral origin of total phosphorus. Thus, the high concentration of reactive phosphate was attributed to the decomposition of organic matter and the release of absorbed phosphate. The average concentration of the reactive phosphate of 35 µg P l^{-1} was about 2.5 times lower than total phosphorus.

(iii) Organic matter and silicate

The upper 40 m depth is characterized by a general concentration of 11.5 mg SiO_2 l^{-1} with an increase up to 13 mg SiO_2 l^{-1} at 50 m depth and a decrease to a minimum 10.2 mg SiO_2 l^{-1} at 60 m depth. The values at 70 and 80 m amounted 12.3 and 11.5 mg SiO_2 l^{-1}, respectively. Similar to the Lake Mariut (Aleem and Samaan, 1969), the vertical distribution of silicate was postulated to be influenced by the physicochemical conditions of the lake rather than by diatom consumption (Saad, 1980). Dissolved organic matter (DOM) content in Lake Nasser was found to increase from a minimum of 1.56 mg l^{-1} at the surface to a maximum of 10.6 mg l^{-1} at 30 m depth attributed mainly to the decomposition of the phytoplankton in the water column (Saad, 1980; Figure7).

In general, a constant concentration of about 8 mg l^{-1} was measured below 40 m (Saad, 1980). It should be noticed, however, that the irregular trend in vertical distribution of nutrients in February was due to the absence of a clear thermal stratification as a result of cooling-induced mixing of the lake water during winter (Saad, 1980).

(iv) Primary production

Large geomorphological and hydrodynamic differences in the extent of thermal stratification and the depth of photic zone were considered the main reasons for different ecosystem characteristics of the main channel of the AHD Reservoir compared to side bays (Abu-Zeid, 1987). In general, rates of biological production in the AHD Reservoir were estimated as high as 8-15 g O_2 m^{-2} day^{-1} from diurnal changes in open water measurements in some side bays (Abu-Zeid, 1987).

Similar, high rates of gross primary production between 5.23 and 13.2 g C m^{-2} day^{-1} were measured in March 1970 whereas, higher rates of between 10.7 and 16.4 g C m^{-2} day^{-1} were recorded in 1979 when the biologically activity zone of the lake extended down to about 4 m (Latif, 1984). However, an average of 10 g C m^{-2} day^{-1} or 3’650 g C m^{-2} yr^{-1} calculated from the above values represents an extremely high rate beyond the highest values measured in the lakes.

The primary production corresponding to an average phosphorus concentration of 50 µg P l^{-1} (Table 4) typically varies between 150 and 250 g C m^{-2} yr^{-1}. It can be considered that the reservoir consists of 5 % side bays (300 km^2) where the production reaches high rates up to 3’600 g C m^{-2} yr^{-1}, and the rest of 95 % main channel (5’700 km^2) with an average production of 200 g C m^{-2} yr^{-1}. According to this scenario, a weighted average primary production of 370 g C m^{-2} yr^{-1} can be calculated. Even though suffering a large degree of uncertainty, the above calculated primary production for the AHD varying between 200 and about 400 g m^{-2} yr^{-1} may represent a better estimate[53].

4.3 Water-born diseases

The creation of AHD combined with changes in the downstream irrigation to a perennial system has caused an increased in the incidence of schistosomiasis (El-Hinnawi, 1980)[54]. The intermediate host of bilharziasia snails (*Bulinus* sp.) were reported to have appeared in the shallow littoral zones of AHD Reservoir in great numbers at the end of 1974 (Entz, 1980a)[55].

In 1942, *Anopheles gambiae* introduced malaria from Sudan in the area of the actual AHD resulting in about 100,000 deaths of which 10,000 occurred in Upper Egypt (George, 1972)[56]. Progressive inundation of the cultivated river valley with rich soils triggered a massive development of chironomid swarms (lake flies) in Lake Nasser within the first 10 years of its existence (Entz, 1980b)[57].

While the relatively calm water of the reservoir favors the spread of some diseases, the rapid water flow through dam sluices encouraged the breeding of a black fly (*Simulium*) carrying a human disease known as river blindness – onchocerciasis (George, 1972). *Culex pipiens*, the vector for filariasis was

[53] Teodoru, C et al (2006) op. cite

[54] El-Hinnawi, E.E. (1980) ""The State of the Nile Environment: An Overview" Water Supply & Management 4: 1-11.

[55] Entz B.A.G. (1980a) op. cite.

[56] George C.J. (1972) "The Role of the Aswan High dam in changing the fisheries of the south-eastern Mediterranean", in Farvar, M.T. & Milton J.P. (Eds) "The Careless Technology, Ecology and International Development".

[57] Entz B.A.G. (1980b) "Ecological Aspects of Lake Nasser-0Nubia" Water Supply & Management 4: 63-66.

reported to be present along with the latter reported *Phlebotomus* spp., vector of the disease kalazar – leishmaniasis (George, 1972).

4.4 Impacts Downstream of the Aswan High Dam

4.4.1 From the AHD to the Delta

It has been shown that, prior to the AHD construction and operation in 1964, more than 93 % of the Nile sediment load was carried to the Mediterranean Sea (Shalash, 1982) – with the remaining 7 percent being deposited on the river bed and on irrigated land. Since the operation of the AHD in 1968, the sediment balance has been drastically modified.

Studies from the eighteenth century, and confirmed by more recent ones, have shown that during the natural hydrologic regime of the Nile River the annual deposition rate on the river bed and the often cultivated side banks was around 1 mm/yr accounting for 7 % of the annual average suspended sediment load (Shalash, 1982). About 24million tons/yr of nutrient-rich sediments were deposited mainly on the Egyptian flood plains before the AHD construction. At present only 2.1million tons/yr are left in the Nile water to be deposited on Egyptian soils (Balba, 1979)[58].

The low sediment content (25 and 40 mg l^{-1}) in the water downstream of the dam combined with more bank exposure due to low water levels accelerated degradation of the Nile channel. Field measurements over a period of 15 years after the AHD construction showed rates of river bed degradation between 2 and 5 cm/yr depending on the rate of decrease in water levels (Abu Zeid, 1987). Similar results were found by Kotob and Mottoleb (1981)[59] after the first 12 years of the AHD operation, when annual bed degradation rates as high as 3 cm yr^{-1} were measured.

In addition to the bed degradation, bank erosion was also observed along the river channel which was partially caused by local efforts for river regulation before closing the AHD (Abu-Zeid, 1987).

[58] Balba, A.M. (1979) "Evaluation of changes in the Nile Water Composition Resulting from the Aswan High Dam" J. of Envir. Quality 8: 37-49.
[59] Kotob, M & Mottoleb, M.M. (1981) "Effect of the Aswan High Dam on the regime of the river downstream Esna Barrage", High Dam Side-effects Research Institute, Cairo.

Table 16. Maximum drop in river bed and water level downstream AHD between 1964 and 1978 (after Abu-Zeid, 1987).

Location downstream from AHD	Distance from AHD [km]	Max. drop in river bed [cm]	Max. drop in water level [cm]
Aswan Dam	6.5	12	58
Esna Barrage	165	25	76
Naga Hammadi Barrage	359	25	75
Assuit Barrage	539	2	55

4.4.2 Impacts on the Coast and Mediterranean Sea

Observations since 1898 at the Nile delta and the littoral zone indicate active coastal erosion processes along the Mediterranean shore. Explained by recent hydrological changes in the Nile River regime, and the missing supply of suspended solids, the costal erosion was recently associated with a general subsidence (Frihy, 1998[60]; Elraey et al.[61], 1995; Stanley, 1996[62])

Studies by Stanley and Wingerath (1996)[63] have shown that clay-sized material (< 2 µm) is the major fraction transported from the lake behind AHD to the river below. Based on kaolinite tracer analyses, this material was found to be of aeolian origin due to erosion of lake-margins and river banks (and possibly wind blown sand).

In contrast to nutrient rich seas such as the North Sea or the Arabian Sea, the Mediterranean Sea is relatively nutrient poor, which contributes to its low level of primary productivity. This is due to the west-east surface current bringing in low nutrient water from the Atlantic and nutrient-rich bottom water to flowing east to west back out into the Atlantic. An additional factor is the low levels of nutrient rich river runoff. The Levantine Basin is relatively isolated by a sill between Sicily and North Africa.

Before the High Dam was built during an average Nile flood the total discharge of nutrient salts was estimated to be 5,500tons of phosphate and 280,000 tons of silicate. The nutrient rich flood water was approximately 15 kilometers wide, had sharp boundaries and it extended along the Egyptian coast and could be

[60] Frihy, O.E. et al (1998) "Change detection of the north-eastern Nile delta of Egypt: shoreline changes, spit evolution, margin changes of Manzala Lagoon and its Islands" Int. J. Remote Sensing 19: 1901-1912.

[61] Elraey, M et al (1995) "Change detection of the Rosetta Promontory over the last 40 years" Int. J. Remote Sensing 16: 825-834.

[62] Stanley, D.J. (1996) " Nile Delta: Extreme case of sediment entrapment on a delta plain and consequent coastal land loss" Marine geology 129: 189-195.

[63]

detected off the coasts of Israel and southern Turkey[64]. This nutrient rich water resulted in exceptionally rich blooms of phytoplankton that provided food for sardines and other pelagic fish.

Following closure of the Aswan High dam the fishery in the eastern Mediterranean suffered a severe decline. The impoundment of the nutrient-rich floodwater at the AHD was postulated as a main cause of this decline. The lack of nutrient-rich Nile sediment deposited in the AHD Reservoir caused a decline in the fish catch from nearly 35,000 tons in 1962 to less than a quarter of this by 1969. Hardest hit were the sardine fishery. From 18,000 tons in 1962, a mere 460 tons was landed in 1968. The shrimp catch dropped from 8,300tons in 1963 to 1,128tons in 1969.

Thirty years on studies reveal that the ecosystem is in fact adjusting (Sayed and Djiken). Catches of sardines have increased and this is an important indicator. However, scientists are at a loss to explain the mismatch between the low level primary productivity and the relatively high levels of fish production. One possible cause is the substitution of natural nutrients in the Nile water by nutrients from chemical fertilizers in drainage waters.

4.5 Assessment of the Extent, Trends and Impacts of Wind Blown Sand Sedimentation

4.5.1 Origins

Map 4 indicates that the most extensive areas of sand are to the west and that the prevailing winds are from the northwest. Both factors, which when combined explain the problem of drifting sand into the Lake.

4.5.2 Extent

The Dam Authority in collaboration with the Environment Research Institute is undertaking some research studies on wind speed, sand dunes movements, types and quantities of sand, estimates of sand volumes which are deposited into the lake using sand traps in 12 stations on the western side of the lake where there are active sand movements. The purpose of this research is to find the most effective ways of solving the problem.

[64] Sayed El-Sayed & van Djiken, G.L. (1995) "The South-eastern Mediterranean Ecosystem re-visited: Thirty years after the construction of the Aswan High Dam", Quarterdeck 3.1, Texas A & M University.

It has been estimated that the moving sand amounts to 700m^3/km annually and that wind blown sand constitutes 1 to 2percent of sediment entering the Lake. Thus, approximately 1.36 million tons are blown into the lake annually.

According to a study carried out by the Public Corporation for the Development of the High Dam Lake of the Ministry of Agriculture and Land Reclamation the woody vegetation in the area is mainly desert scrub including; *Tamarix mannifera* (Tarfa or Abal) which grows very densely and to very appreciable sizes in seasonally inundated areas or in areas which are not regularly inundated to a distance of three kilometers from the lake, *Salsola javanica (G*hazal Tree), *Salsola baryosma* (Khirait), *Acacia ehrenbergiana* (Salam), *Acacia nilotica ,A.nubica, A.seyal, A.radiana, Fedherbia albida, A.laeta, A.tortlis, Silvadora persica, Leptadenia pyrotechnica, Capparis deciduas, Cadaba glandulosa , Maerua crassifolia and Balanites* aegyptiaca. From the air the Tarfa seems to grow in a form of a belt along the lake shore. It is not known how effective this belt of trees is in preventing wind blown sand reaching the Lake.

4.5.3 Trends

It was reported that a main source area for the sand is the Tushka Depression. If a large area of the depression is developed for irrigation it is possible that the amount of sand entering the Lake will be reduced. Moattessem[65] has called for more research in order to determine a more accurate estimate of sand entering the lake. This is currently being undertaken by the AHDA and ERI.

4.6 Low Agricultural and Fisheries Productivity around Lake Nasser

4.6.1 Low Agricultural productivity

There are many causes of low productivity in the areas of and around Lake Nasser, they can be classified as, technical, Economic and institutional problems, but not excluding other problems, i.e. Marketing and Agricultural processing and transportation.

a- Technical Problems:

- Lack of an appropriate soil texture and composition.
- Difficulty of leveling the surface layers; and therefore, slope cultivation is commonly used.

[65] Moattassem, M (2005) "Aswan High Dam Environmental Side Effects", paper presented at Watershed Management Workshop, Bahir Dar, November, 2006.

- Fluctuation of Lake water level during growing season.
- Absence of organic matter.
- Lack of macro-and micro-nutrients.
- Shallowness of top soil.
- Presence of soluble or less soluble salts such as calcium carbonates and gypsum.
- Continual change in the surface layer as a result of wind movement.
- The presence of certain harmful elements such as boron and selenium.
- Salinity and alkalinity problems.
- Drainage problems.
- Lack of research/extension.
- Lack of certified seeds.

b- Economic problems:

These include:

- Lack of sufficient investments in infrastructural facilities. This problem was further aggravated by inadequacy of monetary liquidity, prolonged procedures of lending.
- Inability of the official investments to create integrated settled communities in and around the lake to attract new settlers from the Nile Valley and Aswan-which are already overpopulated and parts of their croplands are lost to urban uses.
- Inaccessibility to credit by the new graduates and beneficiaries thus impeding their ability to fully use their lands.
- Marketing accessibility.

4.6.2 Low Fisheries Productivity in Lake Nasser

There are a number of problems related to the low productivity of fisheries in Lake Nasser. These include:

- Fishermen use illegal fishing methods including nets with mesh smaller than the legal limit.

- Unlicensed boats.

- Smuggling of fish.

- Over-fishing: excessive and indiscriminate fishing occurs in the lake.

4.7 Potential Environmental Issues of Large Scale Development and Settlement in and Around Lake Nasser

4.7.1 Introduction

There are a number of potential environmental issues related to the very significant developments that are proposed for the area in and around Lake Nasser. The proposed developments include:

- Substantial agricultural development around the shores of Lake Nasser including both small and large scale agriculture (para. 3.8.2) and both above and below the full supply level, and involving substantial resettlement of population around the Lake;
- Substantial (500,000feddans) agricultural development in the Tushka Depression, again involving substantial resettlement of population in the development area;
- Mining in the Wadi Allaqi;
- Expanded tourism both on and around the Lake;
- Increase in Lake Transport resulting from the large-scale economic developments.

4.7.2 Agricultural Development around Lake Nasser

There are two main strategies for agricultural expansion. The first is agricultural development above the high water level (182 masl) that will require pumping. Two types of pump are proposed: large fixed electric pumps and small portable motor pumps. This development could be large and small scale. The second strategy is the development of land below the full supply level using residual soil moisture and supplementary irrigation (mobile pumps or temporary wells).

The estimates of suitable land above the high water level vary from 0.103million to 3.82million feddans. Currently the first phase development is envisaged to be 50,000feddans in four designated areas (see Map 9.

Below the full storage level it is estimated that there is the potential to develop 200,000 feddans. Given the seasonal and year-on-year fluctuations in the Lake level and as a consequence the lateral area available for cultivation this figure is not fixed.

There are a number of potential impacts that such a substantial development could have on the environmental with the Lake Nasser/Nubia catchment. The use of fertilizers and agro-chemicals and their leakages in drainage water into the Lake is an immediate and obvious concern. Currently, experience from the Wadi Allaqi indicates that the regular inundation of the Lake and the nutrients it brings with the sediment is sufficient to keep soils fertile,[66] in particular in terms of nitrogen and phosphorous.

However, there is insufficient experience to say that this will be a permanent feature. Whilst, cultivation without fertilizers and agro-chemicals may provide adequate yields for the small-scale subsistence farmer they may not be adequate for the large-scale commercial operation. Given the very light textures of the soils the use of chemical fertilizers could give rise to a serious increase in nitrogen levels in the Lake where eutrophication would be possible outcome. Currently, the levels of substances in the lake are well below the danger levels but the use of insecticides and herbicides could rapidly change this.

Currently, there are strict controls on the use of fertilizer and agro-chemicals close the Lake shore. The Bio-organic Control project at Aswan has developed a number of biological controls of plant pests that will obviate the need to use insecticides and fungicides. However, there is an urgent need to establish a comprehensive system of monitoring of agricultural developments and of water quality in the lake.

Large-scale agricultural development will bring with it a number of additional impacts. There will be a substantial rise in the population: some temporary such as the winter cultivators who come from the middle Nile Valley each year to grow vegetables on the residual moisture, but others permanent such as the labourers and support staff for the large-scale developments. These people will require housing and supporting utilities: electricity and water. This will require careful settlement and supporting infrastructure planning as well as adequate waste disposal facilities to prevent pollution of both the Lake and the groundwater resources.

4.7.3 Agricultural development of the Tushka Project

The Tushka Project aims to develop some 500,000feddans of land using water from the Sheik Fayed canal and from local groundwater resources. Much of this development will be large-scale and thus the numbers of people is likely to smaller than if this was a resettlement scheme for small farmers.

[66] Briggs, J et al (1993) op. cite.

The Government has already installed strict regulations on the use of fertilizers and agro-chemicals. Nevertheless, there will need to be a comprehensive system of monitoring install at the outset if severe pollution of groundwater is to be prevented. Similarly, there is a need for careful planning of settlements and supporting infrastructure and waste disposal facilities.

The modeling by Jeongkon Kim and Mohamed Sultan (2002)[67] to investigate the long-term hydrological impacts of the proposed large scale irrigation development in the Tushka Depression has indicated the danger to the Nubian aquifer of irrigation drainage water causing flooding and salinization. Again, a comprehensive system of groundwater monitoring should be in place at the outset if these negative impacts are to be avoided.

4.7.4 Mining and Quarrying

There is substantial mining and quarrying taking place within the catchment of Lake Nasser/Nubia. Whilst much is of low environmental impact where a number of mining and quarrying activities are concentrated, in for example the Wadi Allaqi Biosphere Reserve the potential for negative environmental impacts increases. The area was a source of gold in ancient times and currently gold exploration is taking place. The Wadi is already linked to Aswan by a tarmac road thus providing easy access.

All applications for mining and quarrying in the lake Nasser/Nubia catchment should be subject to strict environmental impact studies to ensure that environmental damage to the lake and its surrounds does not occur.

4.7.5 Expansion of Tourism

Adding Lake Nubia to tourist destinations around Aswan has considerable potential, especially during the winter months. Already the rebuilt Abu Simbel temple complex is a major tourist attraction by both boat and plane. In 1989 the Government began cooperating with UNESCO in making other archaeological sites available to local and international tourists. During the salvage operations of the 1960s these had been grouped in three locations, the first being close to the western end of the dam and the other two also on the west bank-approximately 100 and 200 kilometers up the reservoir from Aswan. The first site is already accessible as the other two will be once connecting roads are built from the now

[67] Jeongkon Kim & Mohamed Sultan (2002) "Assessment of the Long-term hydrological impacts of Lake Nasser and related irrigation projects in South-western Egypt", J. of Hydrology 262, Issues 1-4, 68-83.

tarred Aswan-Abu Simbel highway. As for the town of Abu Simbel, by the mid1990s it had a total population of approximately 5,000 people.

Currently Abu Symbol does not have a waste water treatment plant[68] although one is proposed. Given the other developments taking place or proposed on the western side of the Lake it is likely the town of Abu Symbol will grow in population. Again, careful planning of housing and infrastructure will be required to avoid pollution of the lake and groundwater resources.

4.7.6 Increased Use of the Lake for Transport

The lake itself is a substantial tourist attraction for boat tours, fishing and boating. Any significant increase in motor powered boats on the Lake carrying large numbers of passengers has the potential to cause considerable environmental damage.

Given the potential for substantial agricultural, tourist and mining development it is likely that commercial lake traffic could increase significantly given the relatively poor road development. This could add to the potential to cause environmental damage.

4.8 Organizational and Institutional Issues

4.8.1 Agricultural and Fisheries Development

There are a number of organizational and Institutional Issues.

- Lack of effective coordination among the authorities concerned with land and water management. The two main Ministries are Ministry of Water Affairs and the Ministry of Agriculture and Land Reclamation.

- Lack of continuity in phases of implementation, which leads to delay in the accomplishment of the entire settlement.

- Lack of collective planning for project management by the real beneficiaries.

- Limited loan repayment programs.

[68] NBI-NTEAP (2005) "Nile Basin Water Quality: Monitoring Baseline report: Egypt", NTEAP.

- Multiplicity of agencies supervising the reclamation and farming process (i.e., ministries of Agriculture, Water Resources and Irrigation, Housing and New Communities and the municipal authorities).

- Absence of an accurate data base with the executive authorities, and a well-defined chronological program for settlement and environmental impacts.

- Absence of Environmental Impact Assessment for development likely to have significant environmental and social impacts.

4.8.2 Forestry Development

The current organizational setup is that The Lake Nasser Development Authority of the Ministry of Agriculture and Land Reclamation is responsible for all agricultural activities, research and extension work in the area. Though an excellent effort is presently being made with regard to forestry activities a specialized section or division with sufficient numbers of specialized personnel and labourers is needed as the expected work volume will increase.

Though agricultural companies and farmers working in the area have established or willing to establish tree shelterbelts, windbreaks and woodlots this needs to be made a legally binding policy. Forest products harvest and removals should be officially controlled to make the protection measures which are to be implemented more effective.

4.8.3 The Need for Integrated Lake Basin Development Planning and Implementation

Given the substantial developments that are proposed for Lake Nasser/Nubia and its environs and its very fragile ecosystems there is clearly a need for a comprehensive and integrated framework for the sustainable management of its land and water resources. The area is within two countries, three Governorates and there are a number of central Government Ministries actively involved in current and planned development activities.

Both Sudan and Egypt have a proprietary interest in the Lake and the existing cooperative activities e.g. in monitoring sedimentation, need to be expanded to encompass a wide range of mutual concerns. These can include joint environmental monitoring of water in the Lake and the Nubian Aquifer, joint monitoring of river flows and suspended sediment and joint Lake planning and management.

5. IDENTIFICATION OF WATERSHED MANAGEMENT INTERVENTIONS

5.1 Potential long term scenarios for sedimentation trends in Lake Nasser

Given that 99percent of the sediment in the Lake is derived from Ethiopia and Sudan it will be vital to monitor closely the potential Impacts of long-term watershed management activities in Ethiopia and Sudan. These including soil and water conservation, water harvesting and small dams, small-scale irrigation; the potential impacts of large-scale water storage infrastructures in Ethiopia and Sudan; and finally the potential impacts of medium-large scale irrigation developments in Ethiopia and Sudan

5.2 Opportunities for extraction and use of sediment deposits

Mohamed El-Moattessem (2005) has reported that the prospect of dredging some of the sediments and using this material for some industrial and/or agricultural purpose has been under investigation by the Nile research Institute. The composition of the sediments has revealed that the sediments have a value for both industrial and agricultural use. Among these include radio-active materials, ceramics and metallic minerals. The sediments are very suitable for the manufacture of bricks and sand. It was found that when processed the sediments could be used for animal food fillers and as a fertilizer.

A detailed cost benefit analysis of both the dredging operation and the various conversions sis required. The report examined various dredging techniques depending on depth and composition of the sediment. Two sites have been identified: the first at Abu Simbel in the main lake channel and the second south of the first but closer inshore. Three dodging configurations were described. The first incorporating a removable cutter suction dredger transporting the dredged material through floating and shorter pipelines upto 1,500m form the dredged site. The second system is similar to the first but dumps the material into a hopper barge. The third system is similar to the second but can operate in depths upto 50meters.

5.3 Opportunities and potential activities to reduce sedimentation from wind blown sand

The meeting with the National Working Group revealed an excellent appreciation of the role of tree shelterbelts and windbreaks as well as the establishment of woodlots in the protection of agricultural land and irrigation canals, increase of agricultural crop production and soil conservation. At a higher level the council of ministers issued a directive for the establishment of a shelterbelt above the 182 meters contour round the lake.

Planting of shelterbelts is already familiar in the area. A shelter belt of 1500 meters for Aswan town is established. In Tushka area at Abu Simbel Agricultural Research Station trials of establishing shelterbelts on irrigation canals and windbreaks around agricultural farms seem to be successful. Such activities have been undertaken by the research station and the Saudi Company for a distance of 30 km. The French project is still considering the feasibility of establishing shelterbelts. Tree species used in the area are:

Casuerina spp.
Acacia sp.
Khaya senegalensis
Leucenia glaucca
Eucalyptus spp.

It can be noted that shelterbelts and windbreaks are essential for the increase of agricultural crops production, protection of irrigation canals and the agricultural land itself. Tree species which are suitable for the site and meet various needs are to be used. Reservation and official registration of all natural Tarfa areas around the lake and its protection will help in creating a belt which can reduce the volume of sand blown into the lake. Using appropriate silvicultural practices and forest management techniques the *Tarfa* can produce good quality sawn timber as well as fuel wood.

5.4 Opportunities and potential activities to support sustainable livelihoods and increased income generation

The proposed interventions are broad and varied embracing work in the fields of agriculture, animal raising, fisheries environment, soil and water conservation, micro- finance, capacity building, institutional strengthening, information technology, better settlement conditions and community development. The goal of these interventions is to improve the socioeconomic conditions, especially farming conditions, and the livelihoods of settler communities living in desert fragile ecosystem in and around Lake Nasser as well as in Eastern and Western deserts. These interventions include:

- Soil and water conservation measures.
- Improved agricultural practices suitable for desert farming.
- Enhance capacity building of agricultural cooperatives to support Lake-shore farming systems and small farmers.
- Study and mitigate salinity, alkalinity and drainage problems in Tushka project, Abu Simble area and around the lake area.
- Provide loans and develop micro-credit-line for farming activities, animal husbandry, and fisheries sector.
- Develop transportation and marketing accessibility, including better means to markets and finance.
- Strengthen the role of research/extension.
- Establish and support partnership and participation of community-based management of natural resources in a sustainable way based on agro-ecosystem.
- Develop the fisheries sector and introduce aquaculture in the khors along lake shores. Monitor different activities in the area and build data base.
- Coordinate work in different fields through vertical and horizontal coordination among concerned agencies, authorities, ministries and NGO's.
- Enforce law and observe regulations of shore farming, fishing, and settlements.

5.5 Opportunities and Potential Activities to Avoid Environmental Damage from Economic Development

A number of current and planned economic activities have been identified that have the potential to cause substantial environmental damage to the lake and its environs. These include large scale irrigated agricultural development, large scale resettlement of people, development of tourism around and on the lake, development of mining and quarrying and increased boat traffic on the Lake,

The Lake and its surrounds encompass three Governorates and the development activities are within the mandate of a number of local and central government departments. On-going research in such areas as irrigated cropping, bio-organic pest control, sedimentation, hydrology, wind blown sand, ecology, sociology and geology is being carried out by a number of national and international organizations, institutes and universities.

There is clearly a need for an overarching organization that can undertake the integrated planning, development coordination and monitoring of activities in terms of their environmental, economic and social impacts. As many of the development activities are at an early stage there is an opportunity to establish such an organization. Given the fact that the Lake is shared by both Egypt and Sudan there is an opportunity to establish a joint secretariat that could undertake joint sharing of information on development intentions and monitoring results.

6. LONG TERM CAPACITY AND MONITORING NEEDS

6.1 Capacity Needs

There is a substantial and well-developed agricultural research station at Abu Simbel. There is a substantial presence in the area of agricultural, water resources and resettlement technical staff. However given the scale and number of agricultural and resettlement developments proposed for the Lake Nasser area it will be important to substantially increase the capacity of these institutions and ministries

6.2 Monitoring Needs

There an urgent need to refine and extend the current sediment monitoring and modeling work being undertaken by Prof. Dr. Moattessem and colleagues at the NRI. This is particularly important in view of the substantial large and small scale water storage, soil conservation and irrigation developments taking place or being seriously considered in the Eastern Nile Basin upstream of Lake Nasser.

There are proposals for substantial in-migration into the Lake Nasser area and the adjoining New Valley area. It will be important that a system of monitoring the environmental, economic and social impacts is put in-place out the outset. This will require the immediate establishment of an environmental, natural resources and agricultural technical information system.

7. DATA GAPS[69]

Although twenty five agencies under seven ministries are involved in water quality monitoring program, there are many gaps as follows:

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

2. 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.

3. Furthermore, environmental data need consistency and continuity over time because it is generally changes, deterioration or improvement that is of interest. Many Egyptian data sets have begun as part of a development project supported by donor funds. Unfortunately many lapses 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 is not available because of lack of enforcement of existing laws.

4. 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.

5. 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.

[69] From "One System Inventory: Environmental Theme – Egypt", Dr. Rifaat Abdul Wahab., ENTRO, January 2006.

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ANNEX 1.

FLORA OF LAKE NASSER

Family / Species	*Habitat*	*Duration*	Uses ١	٢	٣	٤	٥
* *Boraginacaceae :*							
* *Heliotropium zeylanicum*	Auseful sand binder On sandy soil						+
*H.arabainense		Ann.		+			
*H. bacciferum	In sand			+			
*H. ovalifolium	Nile banks			+			
*H.strigosum		Ann.		+			
Gramineae :-							
**Aristida adscensionis*	On sandy soil			+			
**A .adscensionis var .aethiopica*	On sandy ground			+			
**A . adscensionis var. pumila*	In deep sand				+		
**Aristida funiculata*	In sandy plains			+			
**Aristida hiragluma*	In sandy moist ground			+			
**Aristida meccana*	In sandy plain			+			
**Aristida plumosa*	In the bed of a wadi			+			
**A . plumosa var. brachypodda*	Onsandy plain			+			
**A .plumosa var. seminuda*	Onsandy plain			+			
**Aristida raddina*	In sand			+			
**Aristida acutiflora*				+			
**Astenatherum forskalei*	Main channel. W.Dungul.			+			
**Bromus eruciformis*	Canal banks			+			
**Bromus rigidus*	Weed in cultivation			+			
**Cenchrus pennistiformis*	Sandy plains. Between hills			+			
**Chloris virgata*	Weed in cultivation			+			
* Coelachyrum brevifolium	Sandy plateau			+			
**Crypsis aculeata*	Weed in cultivation			+	+		
**Cynodon dactylon*	Waste land,.In sand soil			+			
**Dacty loctenium aegyptium*	Weed in cultivation			+			
**Danthoniopsis barbata*	On hill sides			+			