

TOWARDS A LAKE NASSER MANAGEMENT PLAN: RESULTS OF A PILOT TEST ON INTEGRATED WATER RESOURCES MANAGEMENT

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ABSTRACT

Lake Nasser is of key strategic importance for sustaining Egypt's water demand and it is essential that its water quality is protected from pollution. Rapid development is taking place in all parts of the catchment and may spread equally to the Lake Nasser area in the near future, as foreseen by the Aswan Governorate "Lake Nasser Development Plan" (2002). In 2009-2010, a Pilot Test was performed to implement integrated water resources management (IWRM) approaches and methodologies based on the EU Water Framework Directive (Directive 2000/60 EC) through the definition of reasoned objectives, applied methodologies and standard procedural planning steps inspired to the main principles of the Directive.

To achieve IWRM objectives in Lake Nasser, integrated planning was required, including a broad set of information ranging from an analysis of competent authorities in place and their responsibilities, a description of relevant water body characteristics, an analysis of potential pressures and impacts, and finally a tailored Programme of Measures. A set of indicators was defined to follow the evolution of the water quality status and to identify main trends in environmental changes in the proximity of the reservoir that could impact water quality. Major potential drivers for change were identified, as well as some key parameters and locations, within the reservoir, that need to be closely followed up to refine the interpretation of potential impacts. Finally, a broad range of management recommendations was derived to ensure a sustainable healthy future for Egypt's most important water resource. Currently Lake Nasser enjoys high water quality and faces no threat of degradation due to local sources. The preliminary observations provided by the Pilot Study represent a valuable step towards the definition of a management plan specific to Lake Nasser and illustrate how a reasoned integration of information derived from different disciplines can support progress in water resources management practices in Egypt and can represent an incentive and guidance for targeted capacity development in competent institutions. The IWRM Pilot Test was conducted in the frame of a EU-Twinning Project on Water Quality Management.

Keywords: Water quality assessment and protection, Monitoring, Nutrient loading, Pressure and impact assessment, EU Water Framework Directive.

1. INTRODUCTION

This exercise provided a unique opportunity to test on the ground in Egypt the implementation of methodologies recently developed in Europe; Integrated Water Resources Management (IWRM) made important progress since the introduction of specific requirements concerning IWRM made by the European Water Framework Directive (Dir 2000/60 EC). Testing the IWRM approach under Egyptian situation also aimed at stimulating Egyptian authorities and stakeholders to work more closely together and to develop opportunities that only integrated management approach can produce, in terms of better informed and more generally shared resource planning.

A large team of experts, each responsible for a special portion of the overall outcome, contributed to this research study working side by side with Egyptian officials from the High Aswan Dam Authority (HADA) as well as from the Lake Nasser Development Authority (LNDA) and from the National Water Research Council (NWRC). This joint work served as a demonstration of how specialists from different disciplines can unite their skills and produce a multi-faceted management plan by combining competences including: policy assessment, chemical and biological monitoring, chemical analysis, data management, data interpretation, impacts and pressures analysis, nutrient load modelling, GIS and the design of a Programme of Measures. The Pilot Test focused on estimating the potential contribution of local human activities, present mainly in the northern and along the western shore of the reservoir, to incoming nutrient and pollutants' loads, and their effect on water quality. This exercise did not take into account any activities that are taking place South of the Egyptian border.

Currently, the management of Lake Nasser is under the main responsibility of HADA, under the Ministry of Water Resources and Irrigation. Presidential Decree n. 203 of 2002 provides general guidelines restricting human activities around the reservoir to avoid potential impacts. Information is available on some of the potential pressures that exist in proximity of the shoreline, but there have been no attempts at assessing their cumulative impact on water quality. In 2002, Aswan Governorate issued a "Lake Nasser Development Plan" [1] including the description of the potential status of human activities in 2022. This document was taken as reference to provide an estimate of potential future pressures on water quality.

The specific objectives of the IWRM Pilot Test were:

- 1) To provide legal and organizational support for an improved and better informed water governance framework for Lake Nasser
- 2) To provide support in data management, interpretation, and design of GIS
- 3) To promote stakeholder participation (use of a participative approach for the preparation of a management plan) stemming from competent authorities that supervise human activities on the reservoir and in its immediate proximity
- 4) To propose indicators for a preliminary quantification of the pressures caused by human activities in and around the reservoir
- 5) To establish potential impacts on water quality by providing estimates of pollutants' loading
- 6) To issue recommendations aimed at enhancing monitoring and further assessments that need to be made to control trends of increase in current impacts
- 7) To estimate pressures and impacts according to a year 2022 scenario
- 8) To design a draft Programme of Measures to provide suggestions on how to reduce the potential impact of major pressures identified in proximity of the reservoir.

2. CHARACTERISATION

To achieve an adequate site-specific perspective, some key characteristics relating to the main legislation, the institutional set-up, the physical setting and some key water quality parameters were collected and analysed.

2.1 COMPETENT AUTHORITIES, ROLES AND RESPONSIBILITIES

A large number of actors hold responsibilities at the national as well as the local management level that influence the status of potential pressures as well as the reservoir water quality. Cooperation across sectors is of the utmost importance, as no single authority can solve on its own the water quality issue. That is precisely why the coordination of major policy makers in each sector has to be organized through IWRM. The following list provides an impression of the challenge that needs to be faced to coordinate among a large number of actors.

Administrations holding responsibilities related to human activities in and around Lake Nasser (2010):

- 1) Ministry of Water Resources and Irrigation (MWRI)
- Local actor: High Aswan Dam Authority (HADA)
- 2) Ministry of Agriculture and Land Reclamation (MALR)

- Local actor: Lake Nasser Development Authority (LNDA)
- 3) Ministry of Housing, Utilities and Urban Development (MHUUD)
 - Local actor: Aswan Holding Company for Water and Wastewater
- 4) Ministry of State for Environmental Affairs
 - Local actor: Egyptian Environmental Affairs Agency, Aswan branch (EEAA-Aswan)
- 5) Ministry of Health and Population (MoHP)
- 6) Ministry of Industry (MoI)
- 7) Ministry of Transportation (MoT)
- 8) Ministry of Local Development (MoLD)
- 9) Ministry of Planning (MoP)
- 10) Ministry of Finance (MoF)
- 11) Ministry of Tourism (MoT)
 - Local Actor: Tourism Authority, Aswan branch.

2.2 ENVIRONMENTAL SETTING

Lake Nasser (also called Lake Nubia in its Sudanese portion) is among the largest man-made lakes in the world (480 km long), situated in a desert area with extremely low precipitation and very high evaporation as shown in figure 1. In the Egyptian portion of the Lake Nasser basin population is low, human activities are strictly regulated and their impact is not expected to be cause of concern for water quality.

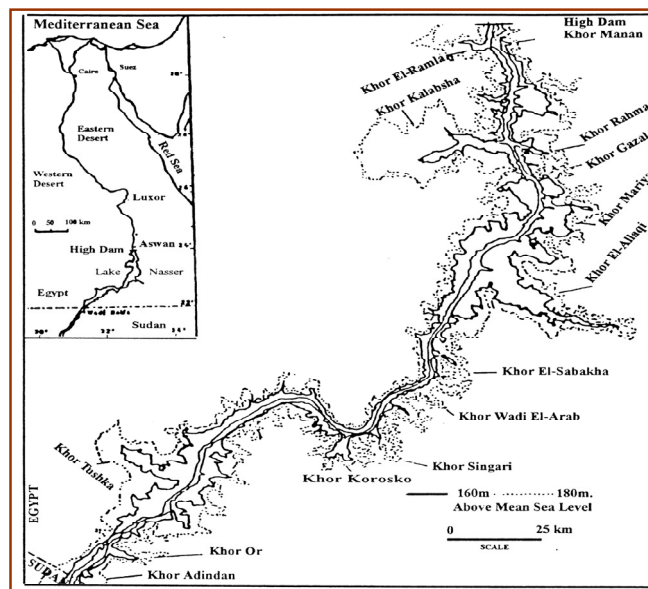


Figure 1. The Egyptian portion of Lake Nasser/Nubia

2.2.1 CLIMATE AND GEOLOGY

The climate of the area is continental with marked variations between summer and winter temperatures as well as day time and night time temperatures. July and August are the hottest months with average minimum / maximum temperatures of 24 and 39.7 °C, respectively. In the coolest months of December and January, temperatures fall to minimum / maximum temperatures of 10 and 21.7 °C. Average humidity varies between 13% in summer and 34% in winter. Rainfall is rare, although rain in the eastern desert occasionally causes flash flooding in the wadis on the eastern bank of Lake Nasser and of the River Nile.

There are three main geological units: the basement complex, the Nubian sandstone and the limestone plateau. The basement complex includes intrusions of igneous masses from the Red Sea range in the Eastern Desert. Various different kinds of rocks became folded, fractured and metamorphosed and then eroded into a huge irregular plateau. Above the basement complex a succession of layers of Nubian sandstone were laid down cemented by lime or silica. The Nubian sandstone thickness varies. Phosphate

beds and limestone deposits are present in the most recent deposits consisting of limestone, sandstone, shale and conglomerate.

2.2.2 HYDROLOGY AND PHYSICO-CHEMICAL CHARACTERISTICS

The limnological characteristics of a reservoir can be subdivided into a riverine, a transitional and a lacustrine zone, exhibiting significant differences in physico-chemical and biological features, and whose boundaries tend to change seasonally. The incoming Nile River has an annual mean discharge of about $2,900 \text{ m}^3 \text{ s}^{-1}$, of which nearly 20% gets lost through evaporation. Lake Nasser has a retention time in excess of 1 year due to the annual flood. Seasonal flow variation is high, and strongly regulated downstream of Aswan. Annual water level fluctuations reach 10 m corresponding to hundreds of ha in terms of surface area. The annual water temperature varies between 11 and 36.1 °C. Lake Nasser is warm monomictic, with differences of more than 10 °C between surface and bottom during summer, and homothermal conditions during winter. Dissolved oxygen concentrations are moderate to high at the surface, but decrease rapidly below 8-10 m in the North and below 20 m in the South, especially during late summer. Transparency can reach values of more than 4.5 m near the High Dam. Total dissolved solids increase from South to North and decrease with depth during spring. The reservoir is well buffered, with pH values comprised between 7.12 and 8.88 [2]; electric conductivity varies between 203 and 261 $\mu\text{S cm}^{-1}$ (data provided by HADA and [2]).

2.2.3 NUTRIENTS

Nitrogen and phosphorus concentrations undergo a pronounced seasonal and vertical variation reflecting a marked seasonality due to Nile River discharge [3]. The N:P ratios indicate phosphorus limitation, however, co-limitation with nitrogen can be assumed in certain periods of the year. Chlorophyll "a" varies between 1.8 and 13.1 $\mu\text{g L}^{-1}$ among different sites [4] indicating that the reservoir can be considered oligo-mesotrophic, with pronounced seasonal variation linked to the arrival of the Nile floods from upstream. Some information on Lake Nasser's water quality is available in reports and scientific papers, but most data are scattered and do not allow to describe long-term trends that should be regarded as a key purpose of water quality management-oriented monitoring. Several questions remain unanswered, such as those concerning the reservoir's carrying capacity from the point of view of nutrients, the correlation between the sediment load and the nutrient load, and the role of sediment diagenesis in nutrient cycling.

2.3 PROTECTED AREAS

A "buffer zone" of 2 km is established around the reservoir by Decree 203/2002, where no agricultural, tourist and industrial activities are allowed to take place. Under Law 102/1983, Wadi Alaqi is recognised as a Biosphere Reserve of international importance that should remain free of any development, disturbance and changes in land-use or activity that may degrade the natural site.

3. PRESSURE & IMPACT ASSESSMENT

3.1 DEFINITION OF POTENTIAL POLLUTION COEFFICIENTS

A quantification of current pressures was carried out by defining pollution coefficients specific to each single human activity, following data extracted from a variety of literature sources and advice summarised by about 30 experts, including: IWRM specialists, agronomists, water resource managers, sewerage engineers, aquaculturists, limnologists and river transport managers, coming from Austria, France and Italy, that took part in this project between 2008 and 2010. A similar pollution coefficient approach based on expert-advice was applied in France in particular for the calculation of an ear-marked tariff imposed on the discharge of polluting effluents produced by different water users (Henry de Villeneuve, personal communication). Further methodological details, describing single sectorial activities, can be found in the reports submitted to MWRI under the Twinning Project Water Quality Management [5]. The main objective of this communication is to estimate the total contribution of different pollution sources and to establish whether they can upset the reservoir's nutrient balance and lead to the development of eutrophication. More precise pressure coefficient can be defined following targeted research on the impact

of single sectors of human activity. The Pilot Test provided a general framework and also recommendations on how these estimates could be refined further [5].

For the quantification of activities, characteristic figures/indicators were employed (See Table 1).

Table 1. Impact indicators based upon a quantification of pressures

Sector	Characteristic figure used
Domestic wastewater	Number of inhabitants
Agriculture	Number and type of cattle
	Surrounded cultivated area "feddans" ¹
Fishery practices	Number of fishermen
	Weight of fish production in cages " t"
Navigation	Number of passenger vessels "day"

This model-based approach was applied to the current situation as well as to 'Scenario 2022' to estimate the load of pollution generated following the development estimates described in the Aswan Governorate's LNDP [1]. An important uncertainty remained the effective translation of the pressures identified on the ground into actual impacts on reservoir water quality. In the case of passenger vessels and aquaculture, discharge effluents produced by these activities reach directly the lake waters; in the case of agriculture and urban wastewater impacts are not entirely direct because only a minor portion of these pressures produces effluents that drain directly into the reservoir, while a major proportion is dispersed through the soil. A careful assessment of transfer factors that can influence the pressure/impact relationship is particularly relevant in the case of agriculture, as this pressure represents the greatest potential pollution source.

3.2 CALCULATING "IN-LAKE" CONCENTRATIONS

The sum of the individual loads (input) generated by the different sectors can be divided by the theoretical water outflow (output) of the reservoir at Aswan (150,000,000 m³ d⁻¹). By dividing the concentration input by the discharge output, this calculation implies that the reservoir itself behaves as a passive storage compartment (i.e., the load of a pollutant measured at the inlet is assumed to equal the load at the outlet and therefore it is divided by the outlet discharge). This estimate, based on the simplistic assumption that no pollutant abatement takes place in the reservoir represents a worst case scenario and was used to define the figures presented in Table 2.

Table 2. Pollutants' loads and estimated "in-lake" concentrations

Pollutant	Pollution load (kg d ⁻¹)		Contribution to in-lake concentration (mg L ⁻¹)	
	2010	2022	2010	2022
<i>Suspended solids</i>	1701	4611	0.011	0.03
<i>Organic matter</i>	999	2755	0.006	0.018
<i>BOD</i>	2259	6068	0.015	0.04
<i>Nitrogen</i>	3837	30698	0.025	0.2
<i>Phosphorus</i>	1015	2411	0.0067	0.016

¹ 1 feddan = 24 kirat = 60 metre x 70 meter = 4200 square metres (m²) = 1.038 acres

Table 2 represents the contribution, in terms of nutrient and pollutant loads, derived from anthropogenic activities that are taking place in the immediate proximity of the reservoir (local sources) and illustrates the theoretical maximum effect (worst case) that pollution loads could have on "in-lake" concentrations, assuming no pollution abatement by in-lake processes (sedimentation, in-lake nutrient cycling, etc.). The pollution coefficients are expressed in g per day ($g\ d^{-1}$) representing an average pollutants' export during a normal activity day. The first column [Pollution load/2010] provides sum of the estimated loads for each parameter. By dividing these figures by the average theoretical outflow at Aswan ($150\ million\ m^3\ d^{-1}$), polluting loads are converted into in-lake concentrations [Contribution to in-lake concentration/2010]. A similar calculation has been carried out for year 2022, based upon estimates of the future development of human activities, provided by the Aswan Governorate [1]. The 2022 in-lake concentrations are significantly higher.

Based on the scenario outlined above, between 2010 and 2022, nitrogen loading is expected to increase from 3,837 to 30,698 kg (by 700%), while phosphorus loading would increase only from 1,015 to 2,411 kg (by 137%). This striking difference between the two nutrients is due to the fact that more than 90% of nitrogen and phosphorus are generated by agriculture, which tends to apply more nitrogen than phosphorus due to current fertilization practices. For both nutrients, our estimates suggest that the potential increase in nutrient loading due to local human activities could bear a significant impact on in-lake concentrations by 2022. For nitrogen, the contribution of local pressures to in-lake concentrations increases 8 times (0.025 to $0.2\ mg\ L^{-1}$) while phosphorus increases only about twice (0.0067 to $0.016\ mg\ L^{-1}$). These trends could significantly affect the potential future lake trophic status as both nutrients seem to control phytoplankton development.

On the other hand, albeit significant, the increase in Organic matter and in BOD represent relatively negligible impacts for the water quality of the reservoir as a whole. A similar consideration can be made in the case of suspended solids. The calculations illustrate a potential increase in loading from 1,701 to 4,611 kg (by 171%). This order of magnitude appears entirely negligible compared to the estimated yearly deposition of about 134 million tonnes of sediment provided by Saad [6] (based on an average yearly inflow of $84\ km^3$).

3.3 ESTIMATING THE CONTRIBUTION OF LOCAL NUTRIENT SOURCES IN RELATION TO THE OVERALL LOAD

The relative importance of local pressures must be assessed in relation to the overall nutrient loading affecting the reservoir, including local sources as well as the load coming from South carried by the Nile River. No precisely quantified estimates exist at the moment for the pollutants' loading contributed by the Nile River. However by applying the Vollenweider Model [7] (Table 3) that establishes a relationship between the average measured in-lake total phosphorus concentration and phosphorus loading, it is possible to obtain an approximate estimate of the total phosphorus loading affecting Lake Nasser.

Table 3. The Vollenweider model equations

Parameter	Equation
Hydraulic residence time (T) “ days”	$T = \frac{VOL}{Q}$
Surface overflow rate (QS) “ $m^3\ d^{-1}$ ”	$QS = \frac{Z}{T}$
Areal phosphorus load (LP) “ $mg\ L^{-1}$ ”	$LP = \frac{LOAD_{TP}}{SUR}$
Mean depth (Z) in m	$Z = \frac{VOL}{SUR}$
Phosphorus concentration prediction (TP) “ $mg\ L^{-1}$ ”	$TP = \left(\frac{LP}{QS}\right) \left(\frac{1}{1 + \sqrt{\left(\frac{Z}{QS}\right)}}\right)$

Unlike for phosphorus, no simple model can be applied to estimate nitrogen loading, due to the complex biogeochemical interactions that characterise the behaviour of this nutrient.

Considering the data provided by Goma [3], a “reasonable” average total phosphorus concentration could be approximately $20 \mu\text{g L}^{-1}$. Based on this estimate, the application of the Vollenweider Model provides an estimated total phosphorus load of $12,000 \text{ kg d}^{-1}$, as reported in Table 4. The estimated average phosphorus loading contributed by the Nile River to Lake Nasser is therefore nearly $11,000 \text{ kd d}^{-1}$.

Table 4. Phosphorus loading from local sources and total phosphorus loading

Current status	Total phosphorus load	$12,000 \text{ kg d}^{-1}$
	load due to local pressures	$1,015 \text{ kg d}^{-1}$ (8% of total)
Scenario “2022”	Total phosphorus load	$13,396 \text{ kg d}^{-1}$
	load due to local pressures	$2,411 \text{ kg d}^{-1}$ (18% of total)

The result portrayed in Table 4 indicates that even if the ambitious Development Plan illustrated in the Aswan Governorate's document [1] was to become reality in 2022, by then, the contribution of local phosphorus sources to the overall phosphorus loading would reach at most 18% of the total incoming load (supposed constant).

3.4 ASSESSMENT OF THE EFFECT OF INCREASED NUTRIENT LOADING

Finally, by calculating the Vollenweider formula “backwards”, it is possible to estimate the “in-lake” total phosphorus concentration that would result from the increased loading estimated for 2022. The calculation indicates this to be comprised between 21 and $22 \mu\text{g L}^{-1}$. The difference between the current ($20 \mu\text{g L}^{-1}$) and the future average in-lake phosphorus concentration (21 - $22 \mu\text{g L}^{-1}$) is below the detection limits for the analysis of total phosphorus in lake water (usually around $5 \mu\text{g L}^{-1}$), therefore this increase will not be detectable by standard monitoring procedures.

4. EUTROPHICATION PROGNOSIS FOR LAKE NASSER

Based upon the calculation of the potential contribution of local human activities to the load of pollutants entering Lake Nasser, and on the other hand upon calculations performed using data extracted from scientific literature [3], it can be concluded that currently the reservoir is unlikely to face a serious risk of undergoing eutrophication/degradation of water quality due to excessive nutrient inputs from local anthropogenic sources.

The current contribution of local pressures to the phosphorus load is $<10\%$ of the overall phosphorus loading, while $>90\%$ is most likely to come from the Nile River upstream. In the near future, local phosphorus loading could increase to a maximum value of $<20\%$ by 2022; however this increase is likely to result in a marginal increase in “in-lake” concentrations because most of the incoming load will be buffered by the self-purification capacity of the reservoir itself (complication, sedimentation and diagenesis). The application of the Vollenweider Model indicates that the increase in “in-lake” concentration will be only marginal and undetectable to standard monitoring practices. A similar fate is expected to be common also to nitrogen loading; however, no quantified estimate can be given at present. This uncertainty should be addressed by a specific assessment programme, given the great potential relevance of nitrogen in limiting primary production in Lake Nasser.

Despite these reassuring results, it should be stressed that the Pilot Study had no means to estimate current trends of increase in nutrient and pollutants' loads coming from upstream. Given their current large predominance, it is expected that the evolution of these loadings will be determinant for the reservoir's water quality status.

5. PROGRAMME OF MEASURES

To keep under control the potential impact of local human activities on reservoir eutrophication, targeted policy lines and measures, specific to each sector were suggested. This included non-structural measures in support of the implementation of structural ones and of their follow-up. Some of these will help refining the overall understanding of critical factors that influence the transfer functions linking pressures and impacts under the specific conditions realised in the case of Lake Nasser.

The following list resumes the principal sectors and objectives under which measures were proposed to keep under control human activities in the Egyptian portion of Lake Nasser, mainly at the northern end of the reservoir, while no provision is made here for activities that could take place at the southern end, in Sudan. A detailed table presenting the Programme of measures is available as part of the results of the recently concluded EU "Water Quality Management" Twinning Project 2008-2011 [5].

Urban/rural wastewater management:

- 1) Define a strategy for the management and planning of current sanitation facilities and define a local sanitation Master Plan
- 2) Develop further sanitation facilities
- 3) Improve management of the secondary effects of domestic sanitation, i.e. sludge in particular, side-effects of wastewater disinfection with chlorine and treated wastewater and sludge reuse
- 4) Improve monitoring of urban sanitation

Agriculture:

- 5) Develop and disseminate standards and guidelines concerning treated wastewater reuse in irrigation, and the reuse of drainage water
- 6) Define and disseminate standards for establishing the exact needs in terms of fertilizers, pesticides, etc., of single crops, assessed in a site-specific context.
- 7) Establish a Code of good agricultural practices with the participation of farmers' representatives
- 8) Develop activities to improve knowledge of the potential impact of agriculture on water quality under site-specific conditions

Navigation:

- 9) Adapt the command/control system to reach a fleet of passenger vessels operating on Lake Nasser with "zero emissions"
- 10) Create a network of dedicated shore reception facilities for solid waste as well as wastewater generated aboard vessels
- 11) Restructure institutional attributions in order to enforce regulations more efficiently

Fishery sector:

- 12) Improve the institutional and organizational framework to better control fishery practices in Lake Nasser
- 13) Promote fish productivity keeping a reduced pollution load discharge

While the measures above address economic activities, a number of concrete recommendations was provided to update and refocus water quality monitoring activities, through a redefinition of mutual responsibilities among local administrations and the establishment of a more regular assessment of the incoming nutrients and pollutants loads coming from upstream.

Targeted recommendations and intervention measures were defined also for accidental pollution control, including a proposal for an oil spill contingency plan as well as specific actions to enhance preparedness, rapid response capacity and transboundary cooperation.

6. CONCLUSIONS

Despite the paucity of reliable data, the application of IWRM principles and methods to the Lake Nasser situation is useful to highlight critical issues and draw some general conclusions about the likely evolution of the reservoir's ecology.

It cannot be over-emphasized that trends of change in nutrient loading should be followed with particular care by the managing authorities. Potential increase in nutrient loading regarded as more or less insignificant for water quality in rivers, may trigger the development of eutrophication in a reservoir such as Lake Nasser, which should be regarded as potentially sensitive to these effects due to its very large drainage basin. These concerns should be carefully considered within the context of the ongoing extension of irrigated areas, urbanization, industrialization and intensification of agriculture in the catchment around the reservoir and also further upstream of Lake Nasser. Experiences made in Europe with regard to fighting eutrophication in Lake Constance, in the North Sea, in the Baltic Sea and in the Danube Delta indicate that it is never too soon for taking adequate precautions to prevent water quality deterioration [8].

The results of the assessment presented here indicate that local human activities bear a limited influence on the overall transfer of nutrient loading into the reservoir. It should be stressed that more consistent data need to be produced, collected and ordered in a validated water quality database, to improve the reliability of the results that are presented here. A number of implementation measures should nevertheless be introduced to control the potential impact of different human activities at local level and to guide further development on the shores of Lake Nasser towards sustainable resource management. To provide these operational measures, it is paramount that local management authorities as well as central ministries may define specific agreements, and share information concerning their activities in relation to water quality monitoring as well as to the monitoring of the evolution of human activities around the reservoir. Special care should be dedicated to assess localized effects of pollution; depending on their individual location, khors have lower flow velocities than the Lake, thus an even more reduced potential of mixing of local effluent discharges and thus an enhanced potential vulnerability to local impacts. Lower current flow, low depth, higher temperatures and more intense nutrient exchanges fuelling higher primary production contribute to create ideal conditions in the khors for fish spawning. This in turn attracts a lot of bird life and fishermen can exploit this resource. Khors represent the most accessible portion of the lake for a range of human activities (fishing, washing, pumping water for irrigation, extraction of sediment for land reclamation) and are therefore increasingly threatened by local pollution sources. Some of the more exposed khors should thus be object of more regular monitoring.

The current good water quality status of Lake Nasser and the low impact due to local (Egyptian) sources indicate that the future water quality status of the reservoir is dependent mainly on potential impacts that could come from the Nile inflow upstream. A targeted monitoring scheme should be put in place to follow more closely incoming loads as well as their evolution over time, taking into account the large variations in nutrient concentrations that accompany seasonal changes triggered by the Nile floods.

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