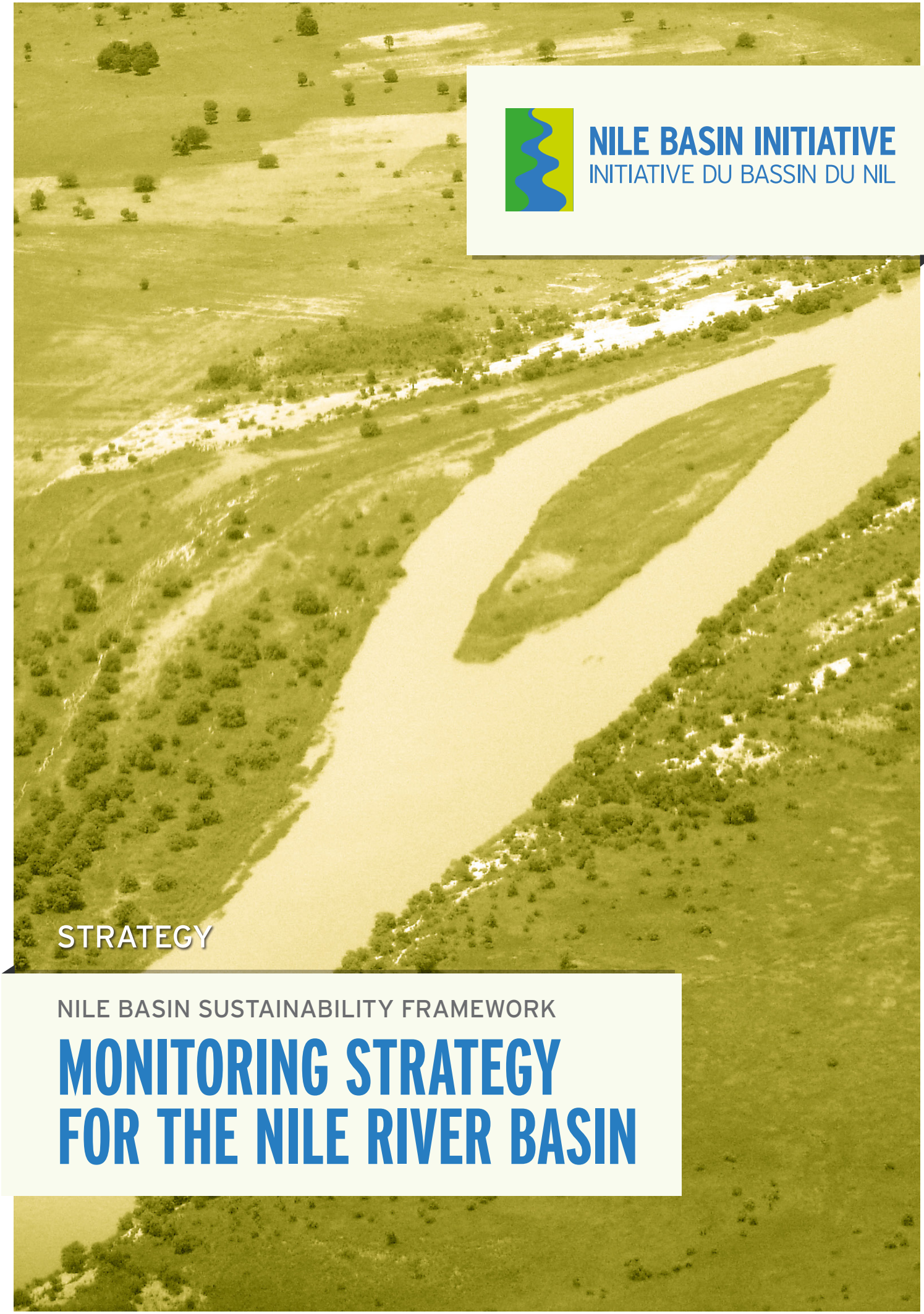

NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

STRATEGY

NILE BASIN SUSTAINABILITY FRAMEWORK

MONITORING STRATEGY FOR THE NILE RIVER BASIN

Photo: Shutterstock

Document Control Sheet

Title	Monitoring Strategy for the Nile River Basin
Document type	☐ Policy ☒ Strategy ☐ Guidelines ☐ Legal and Foundational Document
Prepared by	☐ Nile-SEC ☐ ENTRO ☐ NELSAP-CU ☒ Other: WRPM Project
Status	☒ New Policy/Strategy/Guideline/Legal and Foundational Document ☐ Revision of existing Policy/Strategy/Guideline/Legal and Foundational Document
Revision Date	
Effective Date	5th July 2010

Consideration by Nile-COM/EN-COM/NEL-COM (cross out whichever body is not applicable)	
Date of submission for consideration	5th July 2012
Action by Council of Ministers	The Nile-COM, in its 20th Meeting, under Minute 6.17 considered the Nile-TAC recommendation to approve the Monitoring Strategy for the Nile River Basin, and approved it.
Comments satisfactorily addressed	☐ Yes ☐ No ☒ Not Applicable

Consideration by Nile-TAC/ENSAPT/NEL-TAC (cross out whichever body is not applicable)	
Date of submission for consideration	3-4th July 2012
Action by the Technical Advisory Committee:	The 36th Nile-TAC Meeting that was held from 3-4th July 2012, under Minute 8.13 considered the Monitoring Strategy for the Nile River Basin and recommended that the modality of handling data under the Policy should not conflict with the current Interim Procedures or future data sharing protocols. The Nile-TAC subsequently endorsed the Policy, and recommended it for Nile-COM approval.
Comments satisfactorily addressed	☒ Yes ☐ No ☐ Not Applicable

Responsible Officer: Dr. Abdulkarim H. Said

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

Monitoring Strategy for the Nile River Basin

July 2010

To have a comprehensive suite of river basin monitoring programs in place that supports decision makers, professionals and other stakeholders in the development, management and protection of the shared Nile Water Resources to achieve the Shared Vision of the Nile Basin Countries

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1 Introduction

Speke Bay – Lake Victoria

The Nile Basin Initiative (NBI) has been established to promote and facilitate the mutual and cooperative management of the common water resources of the Nile Basin. A Shared Vision has been developed and adopted, namely:

"To achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources".

Clearly, the development and management of those transboundary water resources in a sustainable, equitable and integrated manner involves complex decision making at local, national and regional levels. Rational and effective decision making must be based upon reliable and timely scientific information that is derived from monitoring of resource status as well as analytical tools that add value to the data thus acquired and support planning and management of the resource. Monitoring is achieved through the establishment and operation of river basin monitoring networks, primarily hydro-meteorological networks, but also include programs to monitor land status and other related important social and physical parameters. In the case of the Nile Basin, this represents a challenge, as the spatial extent of the basin is large and the riparian countries presently do not have the capacity to implement the desirable levels of monitoring activity within their own jurisdictions. Fundamentally, the existing monitoring activities presently in place are not considered adequate.

Therefore, NBI has developed this basin-wide Monitoring Strategy to provide the data required to facilitate the implementation of the various projects and programs of the Nile Basin Initiative. This is to be undertaken in a highly participative way to ensure that all key stakeholders and particularly the Member Countries have ownership and will support its implementation into the future for the benefit of all in the basin.

In the preparation of this strategy, a large number of information sources[1], in addition to regional stakeholder consultation, have been used Three reports are of particular relevance and provide much of the background, analysis and rationale for the Strategy. These are:

- *Situation Assessment Report,* NBI Water Resources Planning and Management Project – Development of Nile Basin Monitoring Strategy Consultancy – Dr Geoff Wright (Consultant) – September 2009.
- *Information Requirements Report,* NBI Water Resources Planning and Management Project – Development of Nile Basin Monitoring Strategy Consultancy – Dr Geoff Wright (Consultant) – September 2009.
- *Strategy to Make Operational the Nile Transboundary Water Quality Monitoring Stations, NBI* Nile Transboundary Environmental Action Project – John Omwenga (Water Quality Lead Specialist, NTEAP) – December 2007.

[1] A bibliography is given in Annex 6.

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2 Background

2.1 Physical and Social Setting

Upper Nile Basin - Rwenzori Mountains Uganda

Lower Nile Basin – River and dunes in Egypt

Ten countries share the Nile Basin's territory, namely Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The region is characterized by poverty, instability, rapid population growth, and environmental degradation

The Nile, though the longest river in the world, with a basin area of nearly 3 million km^2, its runoff potential is small[2]. The basin is also prone to severe variability of rainfall. The basin is home to an estimated 160 million people within the boundaries of the basin, while roughly 300 million live within the ten riparian countries that share and depend on Nile waters. The basin's population is expected to double every 25 years. High population growth and increasing variability of rainfall (due to climate change effects) is forcing many of the countries that hitherto depend on rainfed agriculture, into irrigated farming systems and thereby increasing overall consumptive water demand on the system. The Nile Basin drains from south to north and can be divided into fifteen sub-basins, as shown in Figure 1[3]. This orientation of the River Nile on the African continent means that the extreme ends of its basin are subject to considerable variability with respect to climate. The north for instance (Egypt and Sudan in particular), is characterised by extreme aridity and extensive desert while in the south and east strong rainfall results in lush vegetation, humid conditions and even tropical rainforest in some locations.

The sources of the Nile are located in humid regions, with an average rainfall of over 1000 mm per year. The arid region starts in Sudan, which can be divided into three rainfall zones: the extreme south of the country where rainfall ranges from 1200 to 1500 mm per year; the fertile clay-plains where 400 to 800 mm of rain falls annually; and the desert northern third of the country where rainfall averages only 20 mm per year. Further north, in Egypt, precipitation falls to less than 20 mm per year[4].

Compared with the size of its basin, the total flow of the Nile is very low, at only about 30mm expressed as a depth over the basin. The annual runoff coefficient of the basin is around 4.5% and for comparison, it is just 10% of that of the Rhine. However, this runoff is

[2] *The Hydrology of the Nile* by J V Sutcliffe and Y P Parks. IAHS Special Publication No. 5, 1999.

[3] This division into sub-basins is what is normally used within NBI.

[4] *The Nile Basin,* FAO publication.

far from uniform. This is explained by the fact that a significant portion of the basin comprises arid and hyper-arid zones that are large in surface area yet contribute only negligibly to basin runoff. Added to this are the evaporation losses from major swamp areas that cause up to 30% of the basin's rainfall to be lost before being used for any purpose[5].

Figure 1: Sub-Basins of the Nile

[5] *The Hydrology of the Nile* by J V Sutcliffe and Y P Parks. IAHS Special Publication No. 5, 1999.

2.2 Institutional Setting

The NBI is a partnership initiated and led by the riparian states of the Nile River through the Council of Ministers of Water Affairs of the Nile Basin states (Nile Council of Ministers, or Nile-COM).

The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security.

The NBI started with a participatory process of dialogue among the riparians that resulted in their agreeing on a shared vision: to "*achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects.*[6]

The NBI was formally launched in February 1999 by the Council of Ministers of Water Affairs of the Nile Basin countries. All the riparian states of the Nile, except Eritrea, are members.

The primary objectives of NBI are as follows:

- To develop the water resources of the Nile Basin in a sustainable and equitable way to ensure prosperity, security, and peace for all its people;
- To ensure efficient water management and the optimal use of the resources;
- To ensure cooperation and joint action between the riparian countries, seeking win-win gains;
- To target poverty eradication and promote economic integration;
- To ensure that the program results in a move from planning to action.

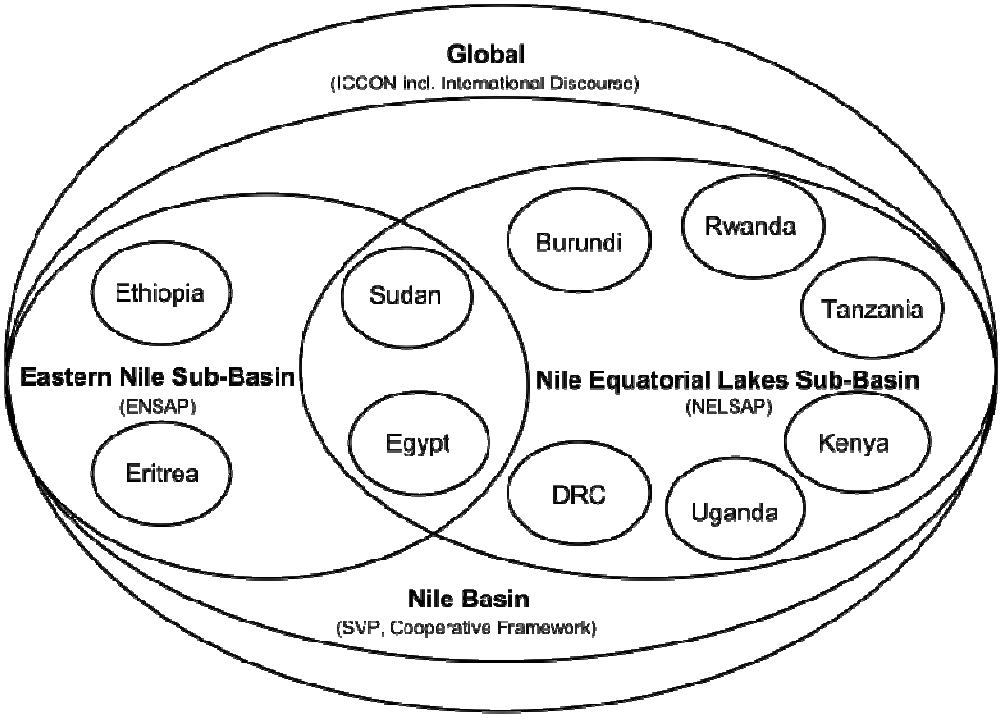
Cooperation and interaction among the riparian states takes place on a number of levels within the NBI framework. This is shown diagrammatically in Figure 2.

The World Bank, the United Nations Development Program (UNDP), the Canadian International Development Agency (CIDA), and several other bilateral and multilateral partner donors support implementation of the Shared Vision Program (see below) and the preparatory activities of the sub-basin level investment projects.

The Nile Basin Trust Fund (NBTF) has been established. It is a streamlined and cost-effective vehicle to administer donor support for the Nile Basin Initiative. The NBTF will support the SVP, the preparation of the subsidiary action programs, and the overall facilitation and general support to program-related activities

[6] Nile Council of Ministers, Policy Guidelines for the Nile River Basin Strategic Action Program, February 1999.

Figure 2: NBI Cooperation and Interactions



2.3 NBI Programs

Cooperation through NBI has been pursued through a participatory approach that has importantly resulted in the adoption of a shared vision and the development of a Strategic Action Program that aims to translate the vision into activities and projects. The Strategic Action Program is being implemented through two complementary programs: a basin-wide Shared Vision Program (SVP) and a Subsidiary Action Program (SAP) at sub-basin level. These programs are listed in Table 1.

Table 1: Strategic Action Program

PROGRAM	SUBPROGRAM / PROJECT
Shared Vision Program (SVP)	
	Nile Transboundary Environmental Action Project
	Nile Basin Regional Power Trade Project
	Efficient Water Use for Agricultural Production Project
	Water Resources Planning and Management Project
	Confidence Building and Stakeholder Involvement Project
	Applied Training Project
	Socio-economic Development and Benefit Sharing Project
Nile Equatorial Lakes Subsidiary Action Program (NELSAP)	
	Kagera Transboundary Integrated Water Resources Management and Development Project
	Mara River Basin Integrated Water Resources Management and Development Project
	Sio-Malaba-Malakisi River Basin Project
	The Lakes Edward and Albert Fisheries Pilot Project
	Regional Agricultural Trade and Productivity Project
	Regional Rusumo Falls Hydro-Electric and Multi-Purpose Project
	Power Interconnection Project between Tanzania and Kenya
	Bugesera Transboundary Water Management Project (Rwanda/Burundi)
	NEL-Water Resources Development project
	NEL Power Trade Project
Eastern Nile Subsidiary Action Program (ENSAP)	
	Eastern Nile Planning Model Project
	Flood Preparedness and Early Warning Project
	Watershed Management Project
	Irrigation and Drainage Project
	Ethiopia/Sudan Transmission Interconnection Project
	Eastern Nile Power Trade Project
	Joint Multipurpose Program

2.4 NBI-Institutional Strengthening Project (NBI-ISP)

Considering that most of the SVP projects would be concluded by the end of 2009, the NBI launched the Institutional Strengthening Project in 2008 to achieve the following overall objective:

"To consolidate an appropriate, effective and sustainable 'one NBI' institutional architecture which competently and professionally leads cooperative planning and implementation of mutually beneficial NBI programs and projects supporting the NBI Vision".

More specifically, the ISP seeks to:

- Strengthen and harmonize NBI corporate management capabilities – namely administrative and financial systems, monitoring and evaluation, reporting and accountability, planning and resource mobilization;
- Explore and design an appropriate NBI institutional architecture - legal foundations, principles covering roles and responsibilities of various institutions (Nile-SEC, ENTRO, NELSAP-CU, NBI National Focal Points, working arrangements with Local Institutions and related regional organisations within the Nile Basin such as LVBC, etc.), facilitating the process of Cooperative Framework negotiations, mainstreaming IWRM functions in the NBI and enhancing water development capacity; and to
- Establish a strong institutional framework of the Subsidiary Action Programs within a broader NBI institutional structure; and to further strengthen the capacity of NELSAP-CU and ENTRO to facilitate the preparation of investments and to promote sustainable development and management of the sub-basins' resources within a harmonized NBI framework.
- Establish and enhance participatory trans-boundary knowledge based sustainable water resources management in NBI following international best practices.

In addition, NBI has developed the **Nile Basin Sustainability Framework** to: (a) provide overall direction for the cooperative management and development of the river basin until such a time that a permanent river basin commission is established; (b) add specific details and operationalises the Nile-COM general principles endorsed in 1999; (c) promote the consideration of the transboundary dimension in riparian states' approaches to water resources management; (d) ensure that all relevant guiding policies and strategies needed to support SAP investment projects are available in a timely manner; and (e) ensure consistency and order in NBI's program of actions.

3 Data and Information Concepts

3.1 Definition

Typical hydrologic monitoring station

It should be made clear at this point what is meant by "monitoring", since different people have different interpretations of the term. The following definition comes from *Strengthening Basin Monitoring for the Nile - A Concept Note* prepared by NBI-WRPM project, and is appropriate.

"Monitoring can be defined as the process of repetitive observing, for defined purposes, of one or more elements of the hydrologic cycle and related processes according to pre-arranged schedules in space and time and using comparable methodologies for data collection. River basin monitoring leads to a better understanding of bio-physical, chemical, and socio-economic states and processes in the basin that are relevant for integrated water resources management.

"River basin monitoring involves regular: (1) acquisition/collection, (2) compilation, (3) validation and (4) storage of data in accordance with the specific objectives of IWRM for a river basin. Thus, it also includes assessment of some aspects of the river basin based on the data collected. In this context monitoring is an important pre-requisite for transparent planning and management, since planning and management activities need reliable information and data. This in turn supports informed decision making processes in IWRM for a river basin."

Beyond monitoring *per se* as defined above, there are also considerations regarding access to the data and information collected during the monitoring process and dissemination to legitimate users.

3.2 Data, Information and Knowledge

It is also important to understand the definitions of data, information and knowledge. The following is a common definition but there are many variations.

Data *represents unorganized and unprocessed facts. Usually data is static in nature. It can represent a set of discrete facts about events. Data is a prerequisite to information. An organization sometimes has to decide on the nature and volume of data that is required for creating the necessary information.*

Information *can be considered as an aggregation of data (processed data) that makes decision-making easier. Information has usually got some meaning and purpose.*

Knowledge *can be thought of as human understanding of a subject matter that has been acquired through proper study and experience. Knowledge is usually based on learning, thinking, and proper understanding of the problem area. It is an understanding of information based on its perceived importance or relevance to a problem area. It can be*

considered as the integration of human perceptive processes that helps them to draw meaningful conclusions.

3.3 Purposes of Monitoring

Within the context of the river basin monitoring strategy, three broad purposes have been identified as given below:

- **Long Term Data Collection (non project specific)** to reduce uncertainty about future conditions and identify trends (such as those due to climate change). This is to minimise the levels of risk in policy development, planning strategies and management of water and related resources. Should also provide sound assessments of the status of and changes to water and related natural resources by establishing initial benchmarks and monitoring trend indicators. This type of monitoring requires extensive coverage of the river basin and should be done regularly over a relatively longer period of time. Trend detection requires even longer records.
- **Provision of Data for Specific Projects** to provide comprehensive and timely data to enable the successful completion of projects and achievement of project objectives. This is most often associated with planning of interventions (structural as well as non-structural) and may necessitate special targeted monitoring efforts. Monitoring is usually limited over time and space. Data may (and should if possible) be integrated into longer term datasets
- **Monitoring for Operational Purposes** to provide and improve data and systems for the operational management of water infrastructure and service delivery, and for managing environmental, public health and social well-being programs. It includes provision of data for operation of hydropower and multipurpose reservoirs, provision of early warning information to protect water users and the community in the event of, say, flooding, and testing for compliance with permits for water withdrawal or discharge of wastewater, etc.

3.4 Monitoring as an Integrated Process

River basin management involves decision making on various aspects of human actions (interventions) to fulfill some higher level goals, such as economic development and growth, poverty reduction/alleviation, environmental protection, and so on. Such interventions could either be structural (which involve constructing physical infrastructure) or non-structural (such as formulation and implementation of new policies). Such interventions are triggered by various factors, such as need for more energy or food (as a result of population growth, or economic activity), responding to natural hazards (floods and droughts), the need to maintain environmental health, and so on. The planning and implementation of interventions require substantial resources to be committed at various levels. Thus, inadequate information is likely to lead to sub-optimal planning and execution of such interventions, resulting in reduced effectiveness.

The ultimate objective of a basin monitoring system should to provide information to support an integrated decision making process, and the actions that flow from such decisions. To facilitate integrated water resource management, the monitoring should focus on all aspects, such as water quantity, quality, eco-system health, and so on, as well as socio-economic characteristics of the basin.

3.5 Drivers of Improved Monitoring and Data Management

There are a number of factors that "drive" the need for and process of improving basin monitoring and associated data management. These need to be taken into account when developing a basin monitoring strategy. They include:

- Demand for more options in planning outcomes
- Integrated management adding complexity and costs to the planning stage (with enhanced benefits as a result)
- Increasing potential for international conflicts over water and need for reliable data upon which to base equitable resolutions
- Requirements for more reliable data upon which to base transboundary water sharing agreements
- Greater community participation in decision making related to basin management
- Need for more effective coordination among different sectors (for instance, energy and water)
- Need for an affordable monitoring investment program and efficient use of available resources
- Trend towards cost recovery of government expenditure from beneficiaries and/or polluters
- Need for improved (accessible and effective) decision support systems
- Climate change - need for assessment of impacts and development of adaptation strategies.

3.6 Monitoring and Information Systems

Easy access to information on the status of water resources and ecosystems and the trends in water use and pollution underpins successful basin management. Water resource managers need to be able to get hold of reliable, up-to-date and relevant information when they need it and in a form that they can use. Data and information is often dispersed among different organizations, heterogeneous and incomplete, and is rarely ideal for objective decision-making. Many public and even private organizations produce and manage data but lack the means and guidelines to exchange, assemble, standardize, summarize and capitalize on the data they and others have. So basin information systems must enhance existing data and information systems. They must benefit all stakeholders and support water resources management. Effective information systems require two main "components", namely the monitoring networks and associated systems, and a decision support system to provide archiving and analytical tools to turn raw data into useful information.

Setting up a basin information system means working on two fronts: first on institutional and organizational issues, and then on the technical issues associated with building an information system. Ideally, basin water information systems and monitoring programs should be set up in parallel, and in the case of the Nile this is indeed happening. The basin information system can then be organized to generate data and indicators on water resources and water use that will allow effective assessment of water management.

4 Issues for Water Management to be Addressed by the Strategy

4.1 Identification of Core Issues

It is clear that information requirements for the Nile Basin are determined by the water resource management issues that need to be addressed and their spatial distribution. As the first step, the core water management issues were identified during the Situation Assessment exercise early in this consultancy. During the stakeholder consultation with the regional Task Force consensus was reached to build on those issues already identified during the comprehensive needs assessment for the development of the Nile Basin DSS; details on methodologies followed are given in the Situation Assessment Report that was completed early in this assignment. These are the so-called "8+2" issues. As a result of stakeholder consultations, one additional issue was added, namely fisheries.

In order to develop effective monitoring programs, not only must account be taken of the key water management issues, but also the spatial distribution of these in order to plan where monitoring should be focused. Clearly, it is not feasible to monitor intensively over such a large river basin. Due to the limited time available for this assignment, it has been decided to assess the spatial distribution of the key water management issues using the accepted sub-basins already defined by WRPM project. While this is a rather coarse approach, it has proven practical and acceptable.

For each key water management issue, a map has been produced that shows the relative importance or impact of that issue on a sub-basin basis. The "value" of the importance or impact for each sub-basin has been assessed by the Consultant using the following information:

- Information provided by key stakeholder representatives at the first consultation workshop (see below);
- Available supporting climatic and socio-economic data, such as rainfall distribution, population densities, and so on;
- Literature related to some of the issues;
- Knowledge and judgment of the Consultant.

A very brief overview of these key water resource management issues, together with the results of an analysis of the spatial variation of the issues across the basin, is included here, as the analysis of the information requirements have been based on these. The spatial distribution of the issues is an important determinant of information requirements.

nda

ter Resources Development

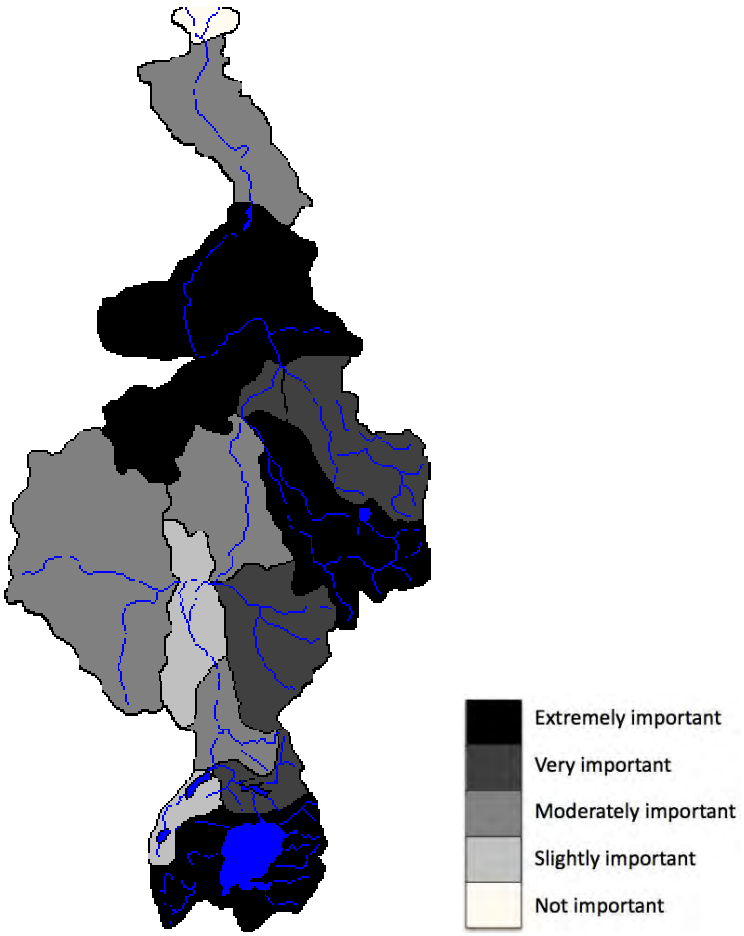
Water use in the Nile Basin is widespread and varied and includes:

- water supply and sanitation;
- agriculture (including a large livestock sector);
- capture and culture fisheries;

- hydropower generation;
- industry and mining; and
- Navigation and tourism.

However, despite the significance of the development that has already taken place, substantial undeveloped potential remains – and this is especially so in terms of irrigation and power generation, both of which represent pressing concerns among the riparian stakeholders. Realization of the remaining potential needs however, greater coordination and cooperation between these stakeholders.

Figure 3: Water Resource Development Issues

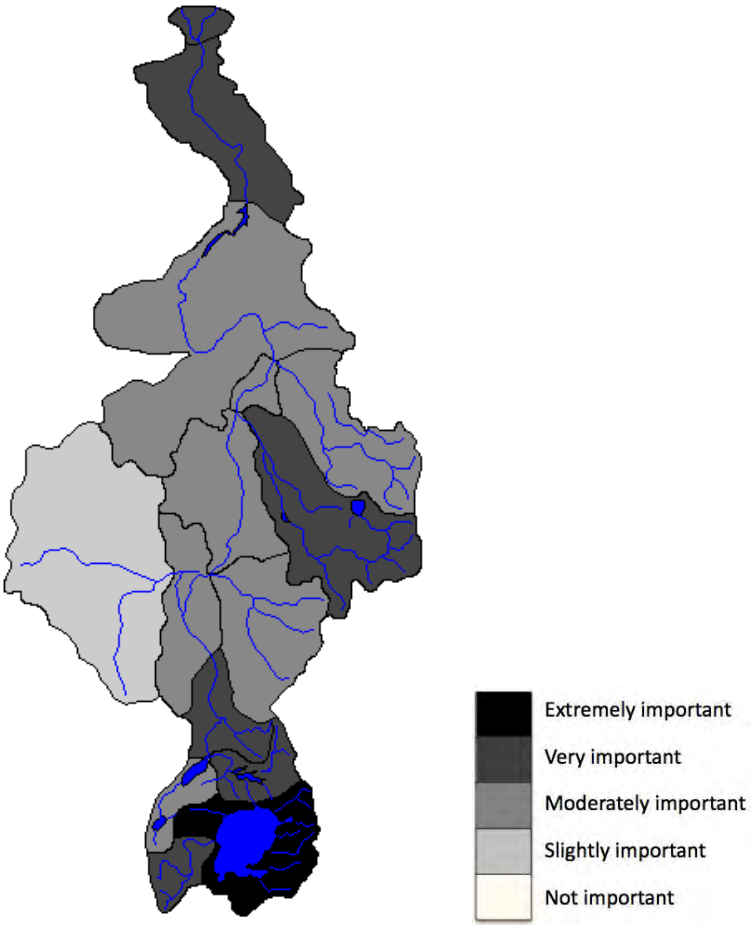


4.3 Optimal Water Resources Utilization

Multiple water uses on lower Blue Nile

This issue relates to improved utilisation of existing water sources, rather than development of additional resources (see above). Strategies to optimize the use of available water focus on demand management, particularly with respect to irrigation urban and rural water supply (including recycling of wastewater and irrigation runoff), and improved operating protocols for reservoirs for conserving water releases and maximizing water available for all uses, including environmental flows and honoring transboundary water release agreements.

Figure 4: Optimal Water Resource Utilization Issues

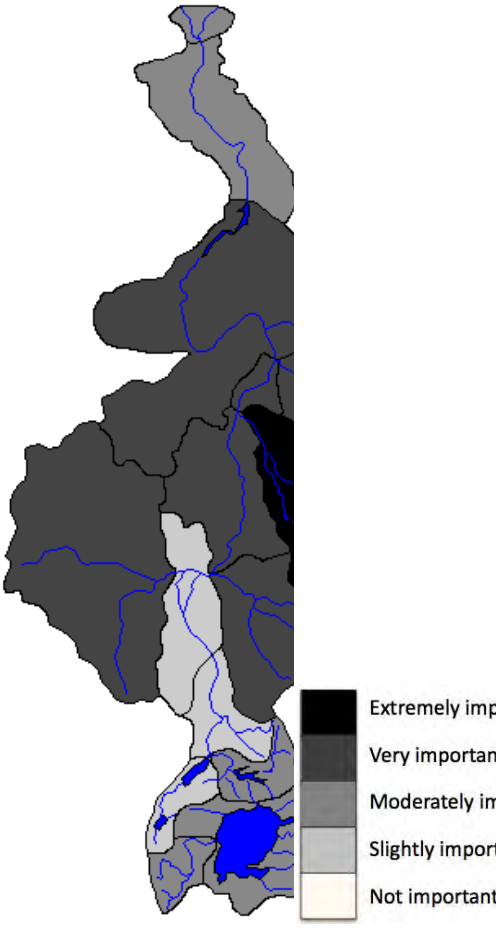


4.4 Coping with Droughts

Drought in Sudan

Water shortages can be caused by natural hydro climatic conditions (droughts) or by human interventions, such as the diversion of water from rivers to serve upstream purposes at the expense of downstream users. Drought is a natural hazard characterized by lower than expected or lower than normal precipitation extended over a season or longer period of time. Farming communities in the Nile basin suffer heavy economic, social and environmental losses almost every year due to drought. El Niño and southern oscillation based early warning system is relatively a recent approach used by the government agencies to assess and respond to drought, but measures are needed to prepare for droughts and to enable communities to cope more effectively when droughts occur. While so-called "drought-proofing" measures, such as the construction of regulating reservoirs (see above under "Water Resource Development"), are important for drought impact mitigation, other more local measures are also required if the impacts of droughts on communities is to be reduced.

Figure 5: Drought-Related Issues



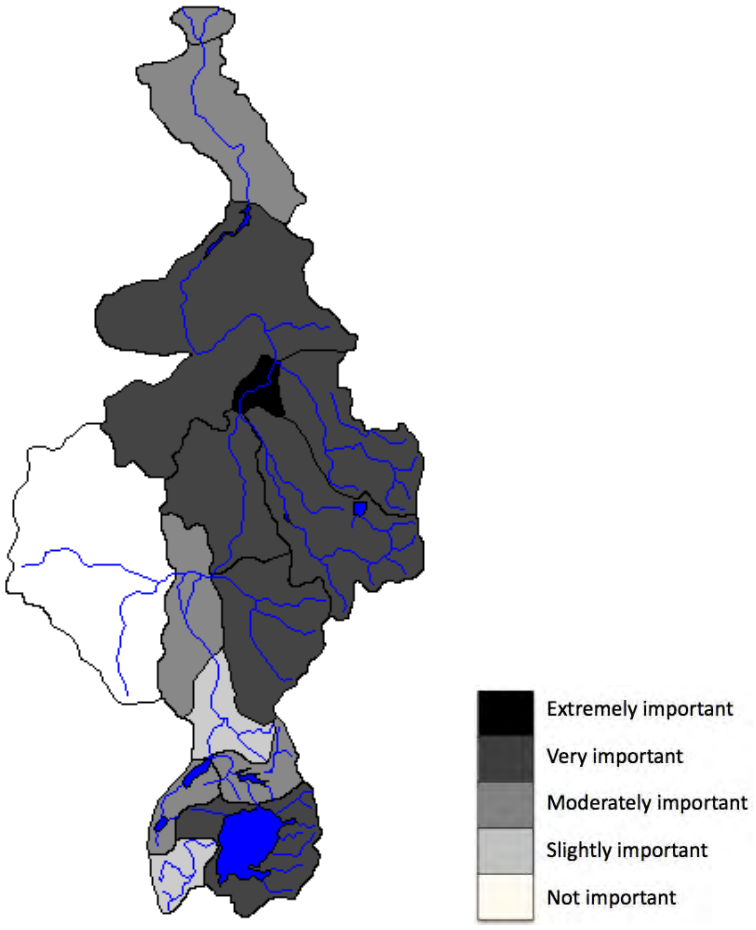
ion – Lower Nile

ping with Floods

Most if not all of the Nile Basin countries rank high among those

exposed to flooding. In particular floods have resulted to significant loss of lives and destruction of property and/or disruption to livelihood. What more these problems impact heavily on the less privileged groups in society, with their limited means of coping with climatic disaster further amplifying poverty and suffering. Measures to mitigate the adverse impacts of flooding and reduce the economic, social and environmental losses to Nile Basin communities are required. These not only relate to structural measures, such as building flood control reservoirs and dikes, but also to non-structural measures, including such things as building community awareness and preparedness for floods, flood forecasting and warning systems, and so on.

Figure 6: Flood-Related Issues



4.6 Energy Development (Hydropower)

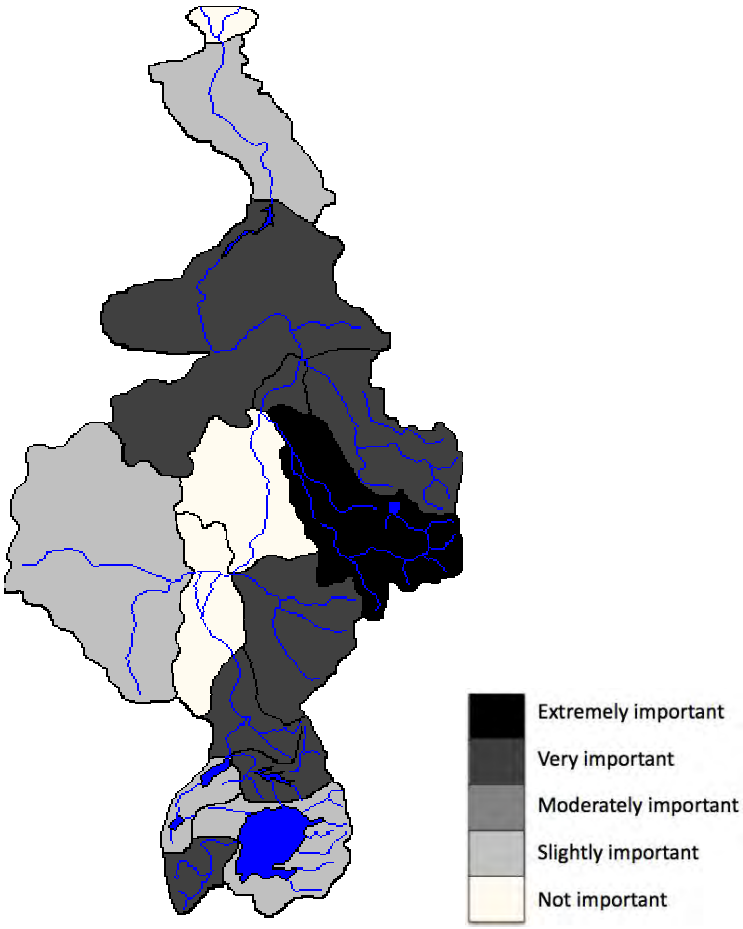
n Falls Dam – Victoria Nile

While hydropower generation is generally considered to be a non-consumptive use of water, there is generally some incremental water losses when a hydropower reservoir is constructed due to additional losses from net reservoir surface evaporation. These incremental losses are generally small compared with the flow in the river on which the

reservoir is constructed. However, it is the change in the hydrologic regime – that is, the timing of outflows from the reservoir compared to the natural situation – that has the greatest impact. Most often, the hydropower plants, and hence outflows from the reservoir, are principally determined by energy supply requirements. However there may be provision in the power plants' operating protocols to release flows for some riparian and/or environmental purposes. Changes in hydrologic regime on an international river can lead to transboundary water management issues and therefore, the operation of hydropower reservoirs requires agreement between upstream and downstream countries.

Another issue is that of optimisation of energy production where there are multiple hydropower reservoirs on shared rivers. "Balancing" the reservoirs – that is, ensuring that the reservoir levels are maintained such that maximum energy production is achieved (subject to constraints arising for the need for riparian and/or environmental releases) – is important. In the transboundary situation, this requires the cooperative development of reservoir operating rules that will maximise the benefit to both (or all) countries involved. Operating to these rules requires monitoring of reservoir levels and inflows, as well as some degree of forecasting of future inflows if optimal operation is to be achieved.

Figure 7: Hydropower Issues



eme - Sudan

nfed and Irrigated Agriculture

Agriculture, including cropping, livestock husbandry and aquaculture, is a critical component of all countries

of the Nile Basin. Droughts and water shortages caused by human interventions regularly impact on the yields of crops and the well-being of livestock. In irrigated areas, to some extent the impacts of water shortages can be mitigated through the supply of water from tanks and reservoirs. However, improved agricultural and irrigation practices are also needed to maximise the long-term benefits of agriculture.

Where large irrigation schemes exist or are planned, improved management of these schemes is a real issue. In other areas, improving water supplies for agriculture, including livestock production and aquaculture, using techniques such as water harvesting is likely to become increasingly important in the future.

Since the spatial distribution of the importance of rainfed and irrigated agriculture issues is different, two maps have been prepared, one for each.

Figure 8: Rainfed Agricultural Issues

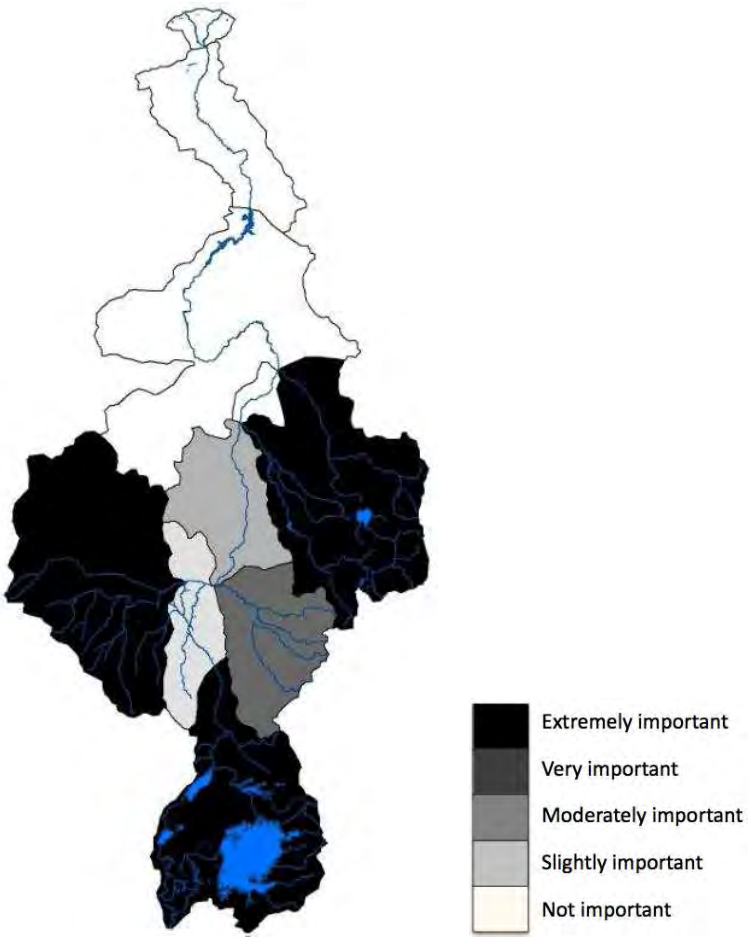
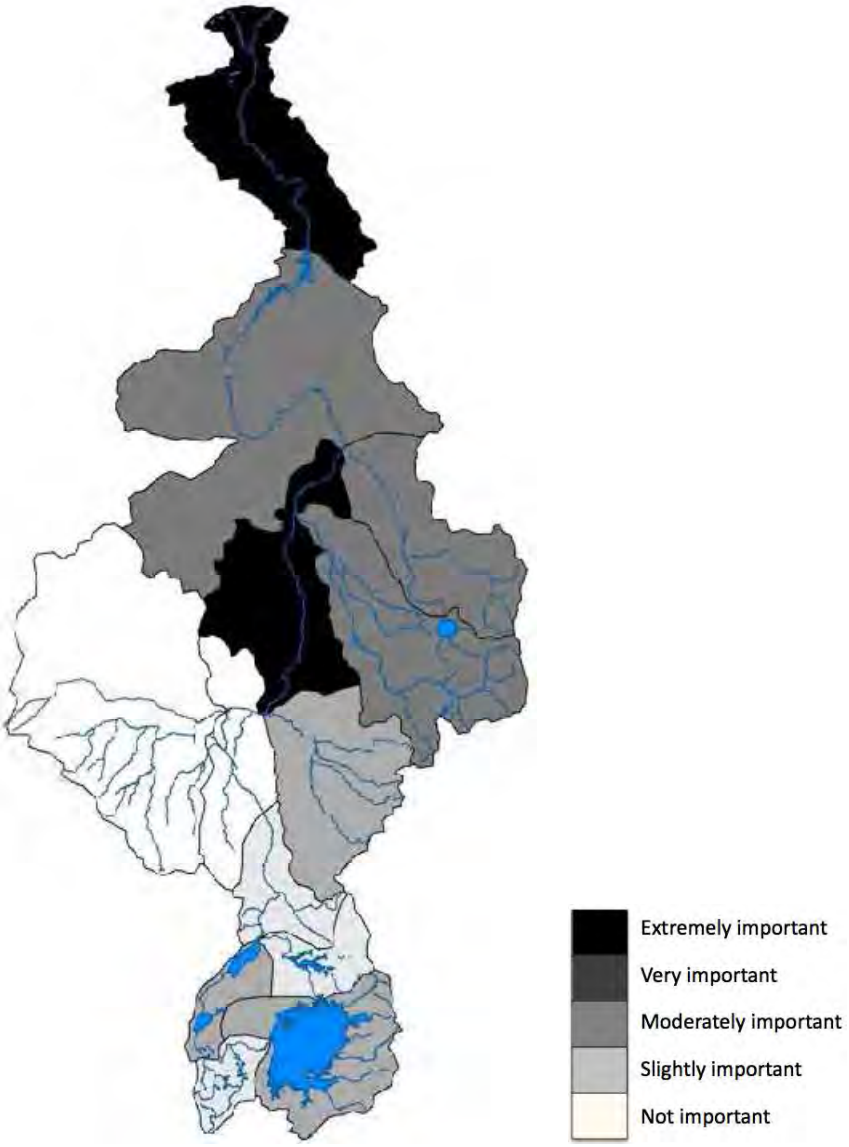


Figure 9: Irrigated Agricultural Issues



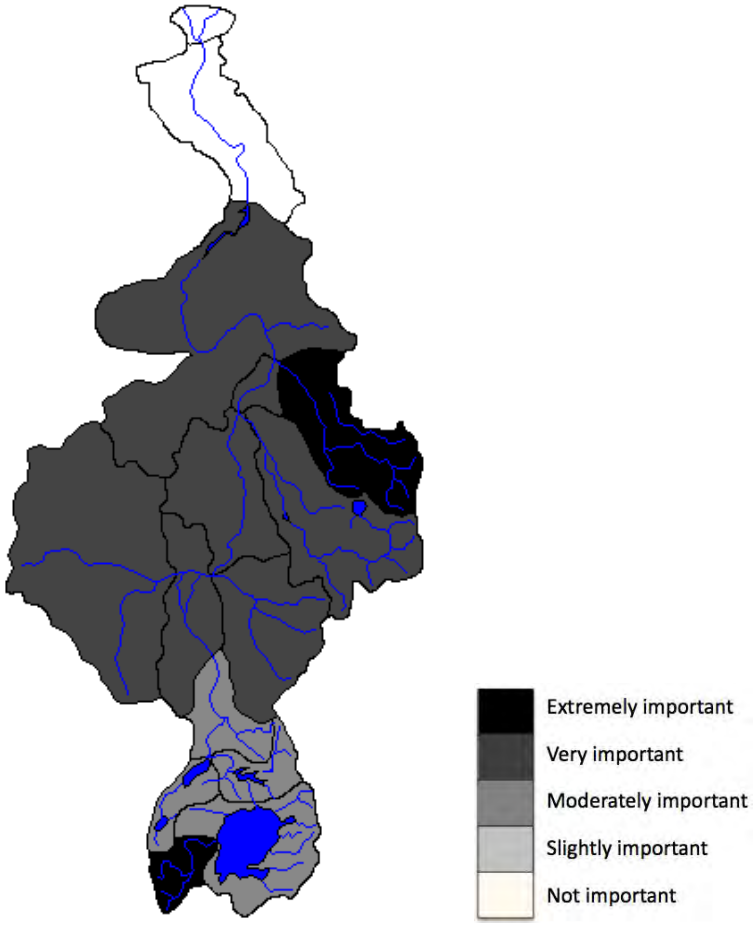
4.8 Watersheds, Wetlands and Sediment Management

Barren catchments - Ethiopia

The following are some of the environmental issues significant in the basin:

- Erosion and sediment wash off from catchments (watersheds) due to natural aridity and/or caused by land use changes (particularly deforestation and inappropriate agricultural practices.
- Degradation of productive agricultural and grazing lands through over-intensive cropping and livestock grazing (in certain areas).
- Sedimentation of water bodies, including wetlands, natural lakes and storage reservoirs, caused by sediment originating from eroded catchments.
- Loss or degradation of wetlands and lakes: water dependent ecosystems throughout the Nile Basin contribute to the stability, resistance and resilience of both natural and human systems to stress and sudden changes.
- Need for transboundary cooperation to protect key habitats. Many key plant and animal species have habitats in adjoining countries, often requiring cross-border protected areas. Aquatic ecosystems are of particular importance in the NBI context.
- Spread of exotic and invasive water weeds. Water hyacinth and other invasive aquatic weeds have spread throughout many parts of the Nile basin, impairing the functions of natural ecosystems, threatening fisheries and interfering with transportation

Figure 10: Watershed, Wetlands and Sediment Management Issues

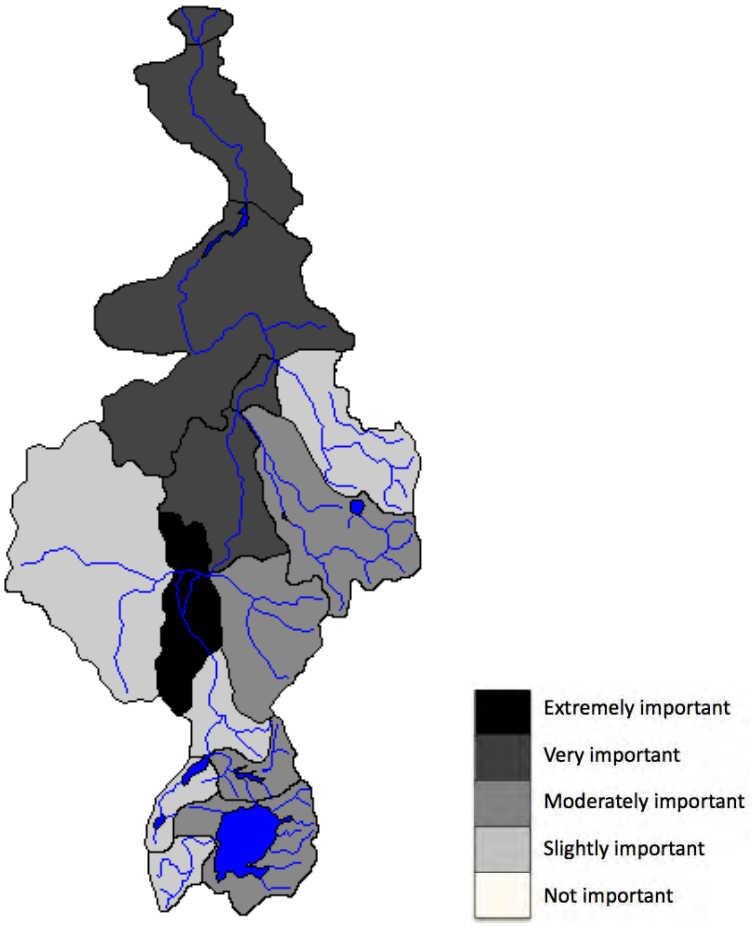


4.9 Navigation

Boat transportation – Lower Nile

Transportation of people and goods by boat, as well as navigation for fishing and other commercial activities (such as tourism) is an important economic activity in many parts of the basin. Navigation is being threatened in some parts of the basin by declining water levels, construction of water control structures, and proliferation of aquatic weeds such as water hyacinth.

Figure 11: Navigation Issues



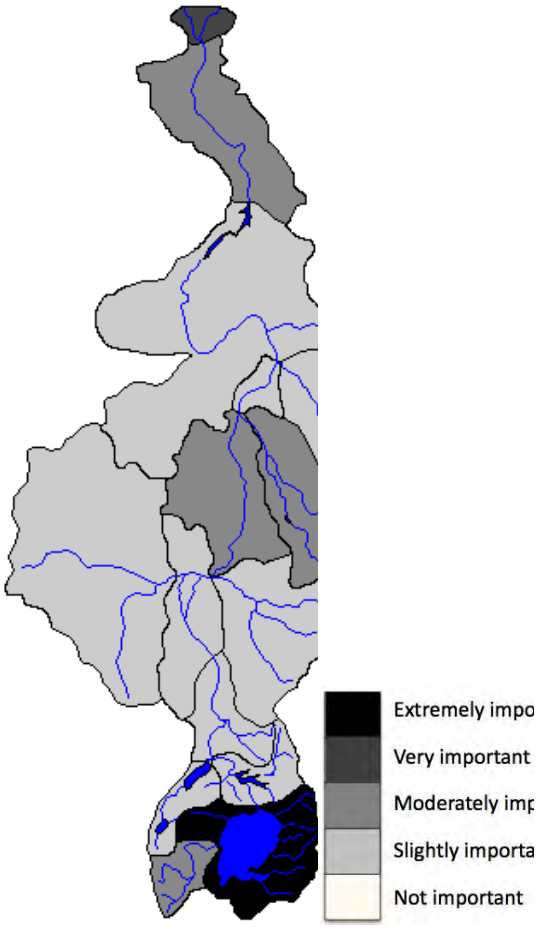
4.10 Water Quality

Collecting stagnant water - Uganda

Cross-border physical or chemical pollution arising from deforestation and soil erosion that increases vulnerability to drought; sedimentation (of wetlands, reservoirs, canals and drains); and produces more severe floods downstream. In addition, urbanization, industrialization and increased use and improper application of pesticides and fertilizers lead to increased runoff and pollution that may adversely impact downstream water users.

Poor water quality also has significant adverse health impacts. Waterborne diseases such as malaria, diarrhea and schistosomasis are among the leading causes of death especially among the old and very young. Their spread is related to a variety of different factors such as increased breeding ground for disease vectors, growing resistance to drugs that fight these diseases, and lack of sanitation infrastructure, often compounded by the lack of adequate hygiene education.

Figure 12: Water Quality Issues



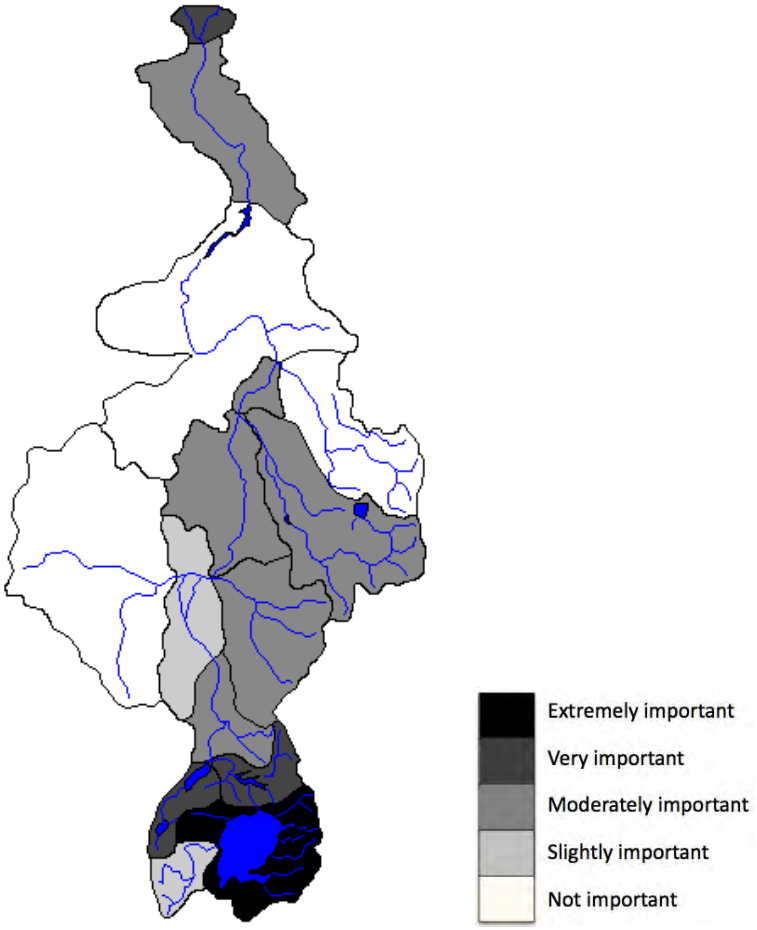
ke Tana - Ethiopia

heries

Fisheries are an important economic activity in the Nile Basin. Poor manage-

ment of water and land resources has a significant impact on these fisheries. Stakeholders have identified two main issues that impact fisheries in a number of the sub-basins, namely pollution and the destruction of fish habitats.

Figure 13: Fisheries Issues



4.12 Climate Change

Possible impact of climate change - desertification

Potential impacts due to climate change are likely to be cross-cutting across all aspects of water resource management in the basin.

The Nile Basin is potentially highly vulnerable to climate change with the areas of particular concern being water resources, agriculture, health, eco-systems and biodiversity, and forestry. The longer-term impacts will include:

- changing rainfall patterns affecting agriculture and reducing food security;
- worsening water security and economic growth prospects;
- shifting temperature affecting vector diseases.

A very high proportion of the basin's agriculture is rain-fed. Agricultural production, including access to food is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition.

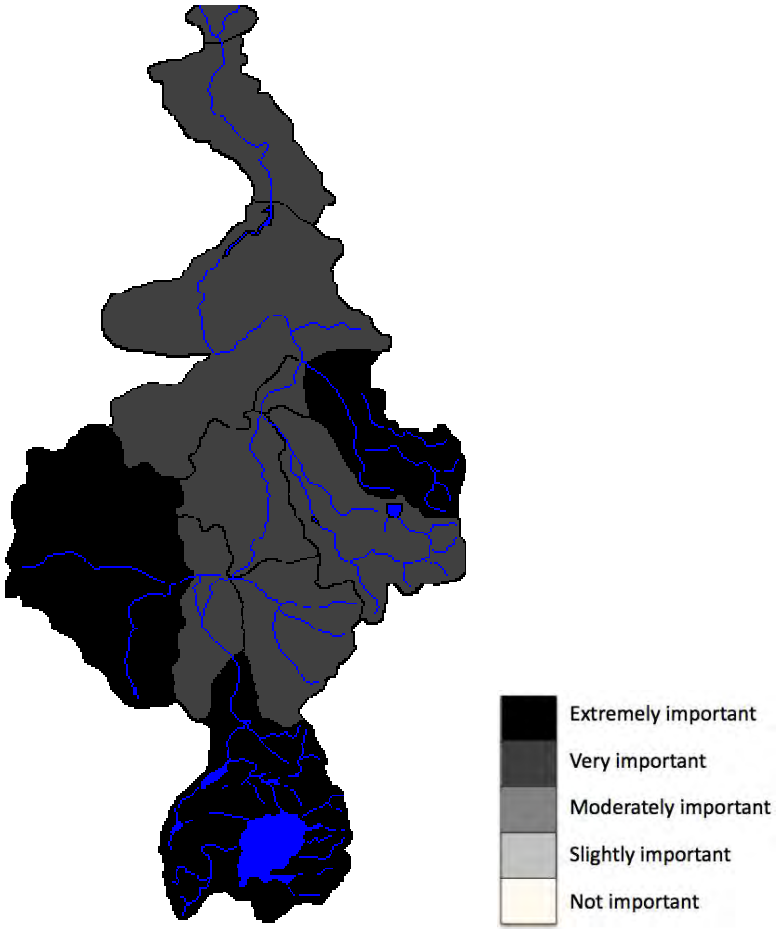
It can be expected that many parts of the basin will face greater water stress in the future. Small reductions in rainfall could cause large declines in runoff. The problem of water scarcity is likely to be even more acute in areas of very high population growth rates (for instance, Uganda) and already high rates of water resource use.

The health effects of a rapidly changing climate are likely to be significantly negative. Parts of the basin are already vulnerable to a number of climate-sensitive diseases such as Rift valley fever, which afflicts both people and livestock; cholera, associated with both floods and droughts; and malaria.

Sea level rise resulting from global climate change and associated flooding to the delta areas could increase force migration of local population. Increased salinisation of coastal is very likely to negatively impact water supplies for domestic and agricultural use.

Local food supplies are also projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued over-fishing.

Figure 14: Climate Change Issues



5 Priority Information Requirements

Information processing at NBI

The information required for effective water resource management encompasses a range of physical and social (including economic) phenomena. Clearly, the hydrologic cycle plays a dominant role in determining the appropriate management policies, strategies and actions, so hydro-meteorological data could be considered the as the "foundation" of river basin information. However, there is a great deal of other socio-economic data that is required for effective and efficient planning, development and ongoing management of a river basin.

As already stated, the information to be collected as a result of the monitoring programs in the Nile Basin must be targeted at the key water resource management issues. It is recognised that information needs are not static and may vary in the future as development of the sub-basins proceeds at different rates, the diversity of water users increases, and prevailing institutional arrangements change. These factors will need to be reassessed periodically to ensure that the monitoring continues to match current needs

In the identification of the information and monitoring needs, the distinction has been made between time series data and spatial data. Time series data applies to a point in space and generally can change quite rapidly over time. Examples are rainfall and discharge. Spatial data on the other hand applies to a region, and in most cases changes much more slowly (for example, topography and land use). Different techniques are required to monitoring these two types of data.

5.1 Data Requirements by Issue

The data required for addressing the key basin management issues, along with the rationale for including these parameters, are set out in the following sections. A summary is given in Table 2.

Table 2: Data Requirements by Issue

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
Water resources development	*Covered under other issues*		
Optimal water resource utilisation	Population density and trends Location of major industries and mines Industrial water use and trends	Discharge	Daily
		Precipitation	Daily at key stations Monthly at others
		Evaporation	Monthly
		Groundwater yield	Annual

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
	Location of irrigated areas Distribution of crop types Livestock numbers by location	Groundwater levels	Quarterly
		Demands for irrigation	Weekly for major schemes Monthly for others
		Use of groundwater for irrigation	Weekly for major schemes Monthly for others
		Demands for urban domestic use	Monthly
		Use of groundwater for urban domestic use	Weekly for major urban centres Monthly for other urban centres
		Demands for industrial use	Monthly
		Use of groundwater for industry	Weekly for major industry Monthly for other industry
		Reservoir/lake level	Daily
Coping with droughts	Location of populated areas Population density and trends Location of major industry Industrial water use and trends Location of irrigated areas Distribution of crop types Livestock numbers by location	Discharge	Daily
		Precipitation	Daily at key stations Monthly at other stations
		Temperature	Monthly
		Relative humidity	Monthly
		Evaporation	Monthly
		Demands for irrigation	Weekly for major schemes Monthly for other schemes
		Groundwater yields	Annual
		Groundwater levels	Quarterly
		Use of groundwater for	Weekly for major schemes

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
		irrigation	Monthly for other schemes
		Demands for urban domestic	Monthly
		Demands for industrial use	Monthly
		Reservoir/lake level	Daily
Coping with floods	Location of populated areas Location of flood control measures	Precipitation	Continuous at key stations Daily at other stations
		River level	Continuous at key stations Daily at other stations
		Discharge	Continuous at key stations Daily at other stations
		Reservoir/lake level	Daily (for routing of hydrographs)
Energy development (hydropower)	Location of hydropower plants and their capacity (existing and planned)	Reservoir inflow	Daily
		Reservoir level	Daily
		Sediment load (into reservoirs)	Monthly
		Energy demands	Daily
Rainfed and irrigated agriculture	Location of irrigated areas Distribution of crop types	Discharge	Daily (for major irrigation schemes) Monthly (for other irrigation)
		Precipitation	Daily (for major irrigation schemes) Monthly (for other irrigation and no-irrigated agriculture)
		Temperature	Monthly
		Relative humidity	Monthly
		Evaporation and	Monthly

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
		evapotranspiration	
		Pesticides	Monthly (in major irrigation schemes)
		Groundwater yields	Annual
		Groundwater levels	Quarterly
		Nutrients (phosphorus and nitrogen)	Monthly (in major irrigation schemes)
		Salinity	Monthly (in major irrigation schemes)
		Groundwater quality	Quarterly
Watersheds, wetlands and sediment management	Location and extent of wetlands Land use (particularly in watersheds) Location of eroded areas	Discharge	Daily
		Biodiversity	Annually
		Key aquatic species numbers	Annually
		Occurrence of invertebrates	Annually
		Sediment load	Daily (at key stations) Monthly (at other stations)
Navigation	Location and extent of water bodies Location and extent of wetlands	River level	Daily
		Reservoir/lake level	Monthly
Water quality	Extent of water weeds (water hyacinth)	**Physical**	
		Discharge	Continuous (at key stations) Monthly (at other stations)
		Water temperature	Continuous (at key stations) Monthly (at other stations)
		Turbidity	Monthly (at key

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
			stations) Annually (at other stations)
		Chemical	
		pH	Continuous (at key stations) Monthly (at other stations)
		Salinity	Continuous (at key stations) Monthly (at other stations)
		BOD (biological oxygen demand)	Monthly (at key stations) Annually (at other stations)
		COD (chemical oxygen demand)	Monthly (at key stations) Annually (at other stations)
		Dissolved oxygen	Monthly (at key stations) Annually (at other stations)
		Total dissolved solids	Monthly (at key stations) Annually (at other stations)
		Nutrients (phosphorus and nitrogen)	Quarterly (at key stations) Annually (at other stations)
		Pesticides	Monthly (at key stations) Annually (at other stations)
		Heavy metals	Monthly (at key stations) Annually (at other stations)
		Hydrocarbons	Monthly (at key stations)

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
			Annually (at other stations)
		Biological	
		Faecal coliforms	Monthly (at key stations)
		Freshwater biota	Annually (at specific sites)

BASIN MANAGEMENT ISSUE	DATA REQUIREMENTS		
	Spatial	Time Series	
		Parameter	Frequency
Fisheries	Location and extent of water bodies Location of commercial and other important fish species Location of breeding grounds	River level	Monthly
		Reservoir/lake level	Monthly
		Water temperature	Weekly
		Dissolved oxygen	Monthly
		Nutrients	Monthly
		Pesticides	Monthly
		Turbidity	Monthly
		Numbers of commercial fish per species	Annually
Climate change	Land cover	Discharge	Monthly
		Precipitation	Monthly
		Temperature	Monthly

5.2 Criteria for Prioritisation

From the discussion in the previous sections and the summary given in Table 2, it is clear that a wide range of information is required in order to manage the water resources of the Nile Basin. However, it is certainly beyond the capacity, and even the mandate, of NBI to monitor all the parameters necessary, or even to guide such monitoring in the member states. Therefore, some form of prioritisation has been required to narrow the focus of the Monitoring Strategy so that a small, but strategic, set of monitoring programs can be planned and implemented under the auspices of NBI.

In order to do this, first a set of criteria was established in consultation with stakeholders in order to provide a rational basis for the priority information as follows.

1. The information should address at least one high priority water management issue.
2. Higher priority should be given to information that will be useful for the management of multiple water management issues.
3. The information should complement what is already collected in programs conducted by the member states.
4. The information should contribute to the management of transboundary water management issues, not just local ones.
5. The information should not contribute directly to the support of commercial activities, although some of the information may have spin-offs for commercial activities.
6. It is feasible for a set of cost-effective data/information monitoring programs to be developed that can be implemented and sustainably maintained under the auspices of NBI.

5.3 Selection of Priority Information Requirements

Using these criteria, the priority information requirements to be included in the Monitoring Strategy are given in Table 3 and are grouped into hydrometeorological and environmental categories. It is stressed that not all information needs can be included in this list because there will be limited resources to implement the strategy and hence it can only address (at most) those issues that satisfy the criteria listed in the previous section. It is stressed that exclusion of any parameter does not imply that it is considered to be unimportant.

Table 3: Priority Information Requirements

INFORMATION / PARAMETER	RATIONALE AND COMMENTS
Hydrometeorological	
Precipitation	Basin information required for water resource management of almost all types Different monitoring frequencies are appropriate for different purposes
River levels and discharge	Basin information required for water resource management of almost all types River levels are required (together with rating curves) to estimate discharge Different monitoring frequencies are appropriate for different purposes
Temperature, relative humidity and evaporation	Basic climatic data required to estimate evapotranspiration from catchments, evaporation from reservoirs and crop water requirements Most often these parameters are measured (with precipitation) at a single meteorological monitoring station
Reservoir and lake levels	Basin information required for water resource management for several purposes
Environmental	
Location and extent of wetlands	Wetlands generally have important environmental values and their extent varies seasonally and year to year Provide critical habitat to many species and important for fisheries and navigation in many areas Often impacted by human actions leading to degradation and diminution
Land cover, focusing on forests and deforestation	While data on land use is valuable in many contexts, considering the issues identified it is deforestation that is of major interest
Location and extent of eroded areas	Erosion, caused by deforestation and other human activities, causes land degradation on the catchments themselves as well as increasing sediment load in waterways and sedimentation in lakes and reservoirs

INFORMATION / PARAMETER	RATIONALE AND COMMENTS
Basic water quality parameters: water temperature, pH, salinity, dissolved oxygen, turbidity	Basic information required for a variety water quality related water management actions These days much of this information can be continuously recorded using compact instream analysis equipment
Special water quality parameters: BOD, nutrients, pesticides, heavy metals, hydrocarbons	Specific information that is more complicated to measure but important to address particular issues, such as urban, agricultural (particularly overuse of fertilisers and pesticides), industrial and mining pollution
Sediment load	Data required mainly for management of lakes and reservoirs

For reference, Table 4 shows information that is important for basin management but considered not appropriate for consideration for inclusion in the Monitoring Strategy at the present time. Of course, this does not preclude the inclusion of these parameters in the Strategy at some future time.

Table 4: Important Information Not Included (for consideration of inclusion at a later time)

INFORMATION / PARAMETER	RATIONALE AND COMMENTS
Hydrological	
Real time rainfall and discharge	This information is required for flood forecasting and flood warning systems. However, it has been agreed that, at least initially, monitoring for this purpose will not be included in the Strategy, as this is dealt with under other NBI programs. However, it could be included at a later time if deemed appropriate.
Groundwater yields	Groundwater has not been identified as a key issue for the basin. It has been agreed that monitoring of groundwater will not be included in the strategy. However, it could be further evaluated in the future and perhaps included as a further strategic monitoring activity for NBI.
Groundwater levels	
Groundwater quality	
Environmental	
Faecal coliforms	Requires lengthy laboratory analysis. Does not address a specific identified key issue.
Location and numbers of commercial fish (per species)	Supports commercial activities and should be the responsibility of the fisheries departments of the member states.

INFORMATION / PARAMETER	RATIONALE AND COMMENTS
Biodiversity	This does not appear to be within the Strategic Goal of the strategy. In any case, it is a very complex resource intensive parameter to measure. To some extent, the monitoring of land cover (under the climate change issue) will provide information to estimate biodiversity in key watersheds.
Extent of water weeds (water hyacinth and other invasive plant species)	This parameter does not contribute to management of any of the identified key issues. It may be possible to estimate the extent of water weeds in conjunction with wetlands monitoring. This will depend on the reflective characteristics of the plants in question and the satellite imagery chosen for the wetlands monitoring.
Operational	
Location and distribution of crop types	Should be the responsibility of those that manage the irrigation schemes – usually the irrigation departments of the member states.
Extraction of water for major irrigation schemes	Should be the responsibility of those that manage the irrigation schemes – usually the irrigation departments of the member states.
Extraction of water for major urban centres	Should be the responsibility of those that manage the water supply – usually a department of each member state.
Extraction of water for major industry (including mines)	Should be the responsibility of those that manage the water supply – usually a department of each member state.
Information associated with hydropower production	Should be the responsibility of the owners/operators of the hydropower plants.

By considering the number of key issues for which each information type is required and by further stakeholder consultation, a ranking of the proposed priority information requirements has been derived, and is shown in Table 5. All of these highest priority information types have been included on the strategy.

Table 5: Ranking of Priority Information Requirements

INFORMATION / PARAMETER	RANK
River levels and discharge (not real time)	1
Precipitation (not real time)	2
Temperature, relative humidity and evaporation	3
Reservoir and lake levels	4
Basic water quality parameters: water temperature, pH, salinity, dissolved oxygen, turbidity	5
Special water quality parameters: BOD, nutrients, pesticides, heavy metals, hydrocarbons	6

INFORMATION / PARAMETER	RANK
Location and extent of wetlands	7
Sediment load	8
Location and extent of eroded areas	9
Land cover, focusing on forests and deforestation	10

6 Strategy Development Process

The process for the development of a strategy for long term monitoring in the Nile Basin to address the identified and agreed key water management issues has followed a basic methodology of strategic planning. Fundamentally, the approach has been to ask the following three questions:

- Where do we want to go (with monitoring in the Nile Basin)?
- Where are we now (that is, what are the existing monitoring activities and issues/ problems)?
- How can we get from where we are now to where we want to go?

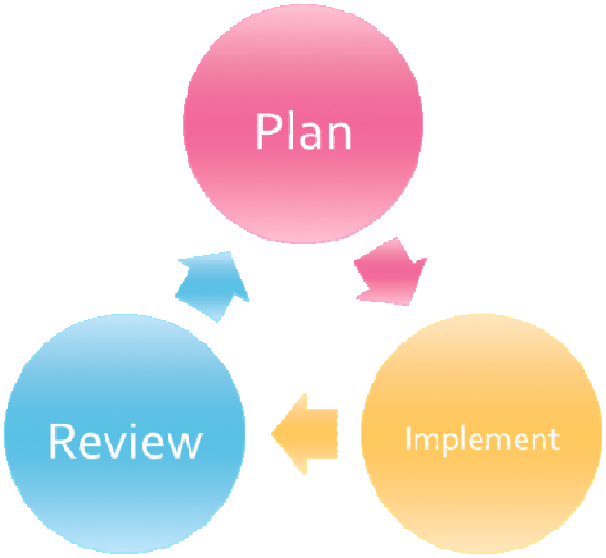
More specifically, the process is shown in Figure 15. Subsequent sections describe the outcomes of this process. Note that a separate Situation Assessment Report documents the current situation with regard to both key water management issues (summarised above) and provides an overview of existing monitoring programs and an inventory or hydrometeorological and water quality monitoring stations throughout the basin.

Figure 15: Strategy Development Process

The process was undertaken in a highly consultative and participatory manner, with close involvement of WRPM staff and experts from the nine Member Countries, led by the Consultant.

It should be stressed that this Monitoring Strategy is the first step in a cyclical process whereby their needs to be a regular revision and updating of the strategy after implementation and review of strategy effectiveness. This is illustrated in Figure 16.

Figure 16: Strategy Development Process as a Cycle



7 Monitoring Strategy Framework

7.1 Strategic Goal

The "destination" for which the Monitoring Strategy is the "roadmap" has been formulated, in consultation with stakeholders as a strategic goal, being:

"To have a comprehensive suite of river basin monitoring programs in place that supports decision makers, professionals and other stakeholders in the development, management and protection of the shared Nile Water Resources to achieve the Shared Vision of the Nile Basin Countries."

The Strategic Goal directly supports the Shared Vision of NBI. This has several aspects, but the most important one is that, for the achievement of equitable sharing of Nile Basin water resources, and to derive equitable benefits for all Nile Basin countries from the water, accessible, reliable and timely information is critical. This Monitoring Strategy will form the basis for improved information collection and management, aided by the Nile DSS presently being developed.

7.2 Key Areas

In a strategic planning exercise of this sort, it is useful to define a number of "key areas" of monitoring that can be used to group objectives, strategies and actions. They make the formulation of objectives and the development of strategies easier, because similar issues generally require similar responses. The key areas group issues of similar kinds.

After stakeholder consultation, it has been agreed that the "core" key areas should be:

- **Strategic Monitoring** including both site-specific "time-series" monitoring and spatial monitoring.
- **Data Archiving and Dissemination** to ensure that data is validated, stored and made accessible to authorised users.

In addition, it is also appropriate to define "cross-cutting" key areas that support the main key areas. These have been agreed as:

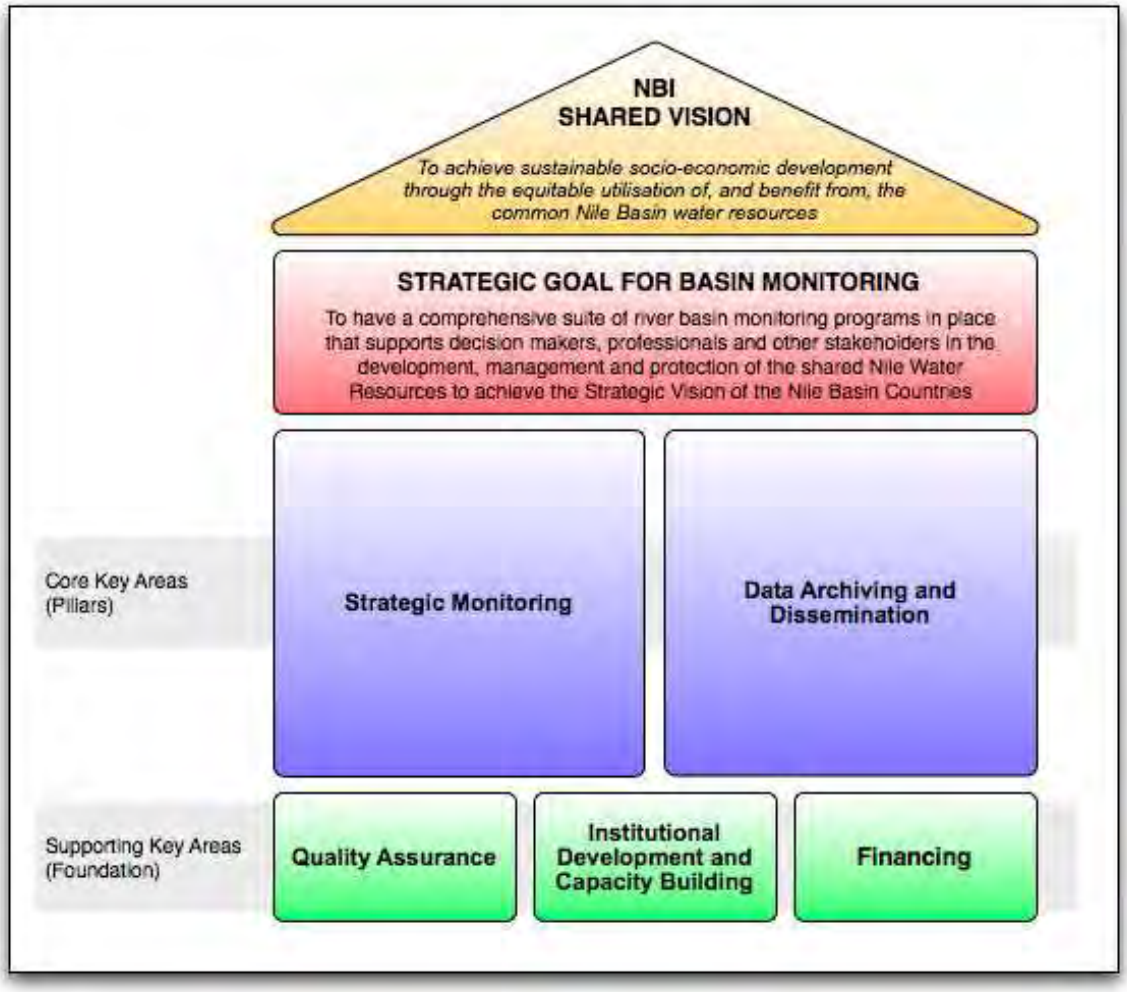
- **Quality Assurance** to ensure that all monitoring is carried out to best practice international standards and the resultant data is of the highest standard (subject to financial constraints).
- **Institutional Development and Capacity Building** to enhance each relevant agency's ability to operate, maintain and enhance the monitoring programs under their jurisdiction. This will concentrate on application of the best technology available (that is feasible to implement), human resource development (specifically, targeted training), and ensuring that the implementation and data sharing arrangements among agencies is clearly defined and appropriate.
- **Financing** to ensure that adequate funds are available from international and local sources to effectively and sustainably operate the agreed monitoring program.

These key areas have been used as the basis of the statement of the Monitoring Strategy in later sections of this document.

7.3 Strategic Framework

The Shared Vision needs to be supported by appropriate interventions (or programs) in each of the key areas if improved and sustainable monitoring is to be implemented and the Strategic Goal is achieved. This can be summarized by the diagram shown in Figure 17. This aims to show that: (i) the Strategic Goal is supported by the core key areas ("pillars"), while the cross-cutting key areas form the "foundation".

Figure 17: Strategic Framework for Nile Basin Monitoring



8 Overall Objectives and Approach

8.1 Overall Objectives

The ultimate objective of a basin monitoring system should to provide information to support an integrated decision making process, and the actions that flow from such decisions (IWRM). To facilitate IWRM, the monitoring should focus on all aspects, such as water quantity, quality, eco-system health, and so on, as well as socio-economic characteristics of the basin.

In order to achieve the Strategic Goal (as defined in Section 7.1) a number of broad strategy objectives have been formulated for the Monitoring Strategy. These are further described in the later sections dealing with the individual Key Areas. The overall objectives can be summarized as:

1. To define status of water resources and catchments, and identify trends.
2. To provide the basis for identifying existing and emerging problems.
3. To provide information to support development and implementation of policies and programs for water resource development, management and protection.
4. To support evaluation of water-related program effectiveness.
5. To enable effective response to emergencies (droughts and floods).

8.2 Overall Strategy Approach

An approach to monitoring to achieve the objectives has been developed that recognises the specific mandate and role of NBI in water management in the Nile Basin, the sovereignty of the Member Countries and their individual policies and programs for monitoring, and the limited funding available for NBI to implement monitoring programs. The main features of the approach are as follows.

8.2.1 Recognition of monitoring as an integrated process

River basin management involves decision making on various aspects of human actions (interventions) to fulfil some higher level goals, such as economic development and growth, poverty reduction/alleviation, environmental protection, and so on. Such interventions could either be structural (which involve constructing physical infrastructure) or non-structural (such as formulation and implementation of new policies). Such interventions are triggered by various factors, such as need for more energy or food (as a result of population growth, or economic activity), responding to natural hazards (floods and droughts), the need to maintain environmental health, and so on. The planning and implementation of interventions require substantial resources to be committed at various levels. Thus, inadequate information is likely to lead to sub-optimal planning and execution of such interventions, resulting in reduced effectiveness.

8.2.2 Focus on monitoring to address strategic transboundary issues related to water resources management

Clearly, the sharing of the waters of transboundary rivers among two or more riparian countries is a key issue for the Nile Basin. Upstream countries may tend to take the view that the water running off their catchments belongs to them and pay little regard to the impacts that water resource developments within their territory may have on downstream riparian countries. Even natural phenomena may cause contention in transboundary water sharing – for example the blocking by sudd rafts of Lake Kyoga in Uganda has raised the lake's water level causing increased evaporation and this is of concern to the countries downstream. The Monitoring Strategy must provide the necessary (reliable and timely)

information to allow decision makers to negotiate and develop rational policies and agreements for the equitable sharing of the limited Nile water resources.

8.2.3 Limited scope of monitoring activities

The NBI was established for the mutual and cooperative management of the shared water resources of the basin and plays a facilitating and coordinating role in basin management. In respecting the sovereign rights of the Member Countries, it has no executive powers over the activities of those countries. In the context of water resource monitoring, NBI must limit itself to "strategic" basin-wide monitoring programs and leave more detailed and location specific monitoring activities to the Member Countries. Prioritisation of data monitoring activities to be undertaken is therefore critical to ensure that NBI is using its limited resources for the best impact to achieve the SV. Even within this strategic context and with the intervention of NBI, responsibilities for installation and maintenance of monitoring networks must remain with the Member Countries while NBI can provide capacity building and some funding to assist them.

8.2.4 Appropriate cost-sharing mechanisms

Funding is highly likely to be a major constraint on the ability of NBI and the Member Countries to implement the Monitoring Strategy. NBI relies predominantly on international donor assistance, with some minor contributions from the Member Countries. The Member Countries themselves are generally relatively poor and unable to afford expensive monitoring programs and high technology. Accordingly, appropriate cost-sharing and fund generation mechanisms must be developed if the Monitoring Strategy is to be successful.

8.2.5 Use of existing monitoring sites where practicable

An inventory prepared by NBI with the cooperation of the Member Countries shows that there are already many monitoring sites that have been established for hydrometeorological and water quality data in the basin. Unfortunately, for a number of reasons, many of these stations provide sub-standard data or are no longer in operation at all. In order to implement the Monitoring Strategy in the most cost-effective manner, existing stations in strategic locations should be upgraded and made effectively operational. However, some new fixed stations may need to be established at strategic locations.

8.2.6 Use of remotely sensed data

"Fixed station" monitoring (of hydrometeorological and water quality parameters, for example) will be insufficient to satisfy the strategic data requirements already identified. Other strategic information will to be gained through acquisition and processing of remotely sensed data, mainly satellite imagery.

8.2.7 Support of a common Regional Knowledge Base and data exchange

NBI is in the process of establishing a "central" database to hold key information – the Nile Basin Regional Knowledge Base. The Monitoring Strategy will support this process. Information from NBI's strategic monitoring programs proposed under the Strategy will be incorporated into the Regional Knowledge Base. In addition, formal mechanisms need to be established so that information from other sources, such as NBI projects, selected data from Member Country programs, data collection programs implemented under non-NBI programs and projects, and so on, can be also incorporated into the Regional Knowledge Base.

8.2.8 Appropriate access and dissemination arrangements

The Monitoring Strategy will be of little practical value, and will not contribute to the achievement of the Shared Vision unless the data collected at part of its strategic monitoring programs is made accessible and disseminated to water managers, researchers and other valid users throughout the basin and elsewhere. Therefore, this matter must be addressed specifically as part of the Strategy.

8.2.9 Provision of support to Member Countries

It is not proposed (and in any case not feasible) for NBI under this strategy to take over monitoring responsibilities and activities of the Member Countries. However, the Monitoring Strategy should provide for NBI to undertake the necessary supporting activities, including training and other forms of capacity building in order that the Member Countries can effectively contribute to the achievement of the agreed Strategic Goal.

8.2.10 Sustainability of the monitoring network

The long-term sustainability of the monitoring network once established is of paramount importance to release the benefits envisaged from the establishment of such network. Key elements of the sustainability include equipment maintenance, continuity of observations, archiving, processing and dissemination of the data collected from such network.

It has been envisaged that, while the initial establishment of the network shall be largely supported through development partner support, the day-to-day operation and maintenance of the network largely depends on the commitment of NBI countries.

In addition, for the data collected through these networks to be used to support the cooperation, the Nile-Sec should make sure that country commitments are in place to avail the data collected through these network.

Therefore, as part of the implementation of the strategy, the Nile-sec as implementing body at regional level shall secure the necessary commitment from NBI countries for operating and maintaining the stations as well as availing the data to NBI. In this regard, the recently endorsed Interim Procedures for data sharing and exchange shall be used and expanded if the need arises.

8.2.11 Phased approach to implementation

The Monitoring Strategy is comprehensive and it will be infeasible to implement all the sub-strategies and actions proposed simultaneously. Therefore, a phased approach must be adopted, so that the priority actions are implemented in the short term, with the others implemented in the medium and long term. Since the Strategy will to a large extent be implemented by a series of projects, appropriate “packaging” of the actions is of benefit.

8.2.12 Tapping of global knowledge portals

The Internet hosts numerous "knowledge portals" – web sites that serve as directories to sources of information on a wide variety of environmental and social information – that can be tapped to supplement the information derived from the monitoring programs to be implemented as part of this Strategy (see Chapter 9). A good example of this is related to climate change. While climate change modelling is well beyond the scope of the Monitoring Strategy, the results of such modelling will be required to make future water management decisions within the Nile Basin. There are several sites that can provide projections of climate change under a variety of different scenarios. These should be "monitored" and used as sources of relevant information when required.

8.2.13 Information as an Asset

Information is an asset, and needs to be managed in accordance with asset management principles. This stems from the fact that: (i) investment is needed to create information, through monitoring programs, archiving systems and analytical processes; and (ii) use of reliable information can result in economic and financial benefits. Accordingly, the initial investment needs to be planned and a long-term strategy developed (as is being done in this instance). Implementation of the strategy needs to be effectively carried out, and the investment protected by suitable asset management programs, including maintenance, enhancement and so on. These should cover not only the physical infrastructure associated with information production (monitoring stations, communications systems, computers, and so on), but also the organisational "capital" – human resources and management systems, for instance, and other essential components such as operating protocols, dissemination and sharing arrangements and so on.

9 Key Area 1: Strategic Monitoring

9.1 Rationale

Since it is not feasible – nor desirable – for this Strategy to attempt to cover all monitoring within the Nile Basin, having a number of "strategic networks" for monitoring of the priority parameters (see Table 3) and the computation of key indicators is considered to be the cornerstone of the Monitoring Strategy. These networks should be designed, implemented, operated and maintained under the auspices (guidance and provision of limited support) of the NBI. Funding arrangements area addressed under Key Area 8.

The data and information provided by these strategic networks should be comprehensive, but will be limited by the resources available to NBI and the Member Countries. High quality of data should be expected because of the leadership of NBI. In turn, Member Countries will benefit from the improved data collected. Links to the NBI Regional Knowledge Base and the DSS will also be important.

A wide range of technology is available for monitoring the priority parameters proposed in this Strategy. Some of the technology available is highly sophisticated, with a high degree of automation, but it is expensive and requires a secure environment in order to operate without problems. Therefore, the appropriate technology to implement the monitoring programs proposed in this Strategy may not be "state-of-the-art", but rather technology that can be reliably operated in the Nile basin context, which means that the environment and conditions under which the equipment is deployed can be hostile for natural or man-made reasons. Under this Key Area, actions are also proposed that attempt to maximise the long-term viability and reliability of the strategic monitoring networks.

9.2 Objectives

The following are the objectives for this Key Area:

1. To have in place a number of programs for strategic monitoring implemented and operated under the auspices of NBI (including fixed station monitoring and remotely sensed data acquisition).
2. To have a mechanism for rapid assessment of the environmental and hydrometeorological status of the basin to inform decision makers and other key stakeholders about basin health.
3. To provide adequate data and knowledge for assessment of impacts due to climate change and the development of adaptation strategies.
4. To provide adequate data for the "technical resolution" of transboundary water (quantity and quality) issues.
5. To maximise the use of data available from "external" sources

9.3 Sub-strategies and Actions

In order to achieve the objectives in this Key Area, the following strategies are to be adopted.

9.3.1 Establish a strategic network of hydrologic monitoring stations on the main reaches of the Nile and the main tributaries.

Such a network should be implemented and managed under the auspices of NBI. This will involve the upgrading of some stations presently operated by Member Countries (and perhaps the establishment of a small number of new stations in strategic locations) to be maintained and operated by the respective Member Countries. As a minimum, the stations should measure water level (preferably instantaneously) and discharge (that is, the sites

should be rated). The proposed locations of the stations to be included in the strategic hydrologic network are shown in Figure 18 and the stations are listed in Annex 1.

This proposed network of 29 stations, including 7 new stations, is based on somewhat limited information. However, the selection of stations to be included has been based on the following criteria:

- A broad coverage of the basin, particularly as for virtually the whole basin discharge monitoring is deemed to be of very high or extreme importance.
- To include, to the extent possible, existing stations with long periods of historical records (note that from the inventory of existing monitoring stations compiled by NBI from the responses of Member Countries, it is not possible to ascertain the length of record for some stations).
- Stations sited at key locations in the basin that will yield data to be used to compute main stream and tributary flow contributions and for transboundary water management. This will not necessarily mean that all tributaries will be monitored directly, as long as indirect methods (for example, addition and subtraction of flows) can be used.
- To provide the ability to do water balances of major lakes and reservoirs.
- To include some small catchments to be able to assess local catchment characteristics, particularly in degraded catchments.
- To have a spread of catchment sizes to enable regional hydrological analysis.
- The selected sites are accessible – that is, there are no major limitations on access that would preclude the establishment and routine operation and maintenance of a monitoring station.
- The sites have been either suggested or confirmed by the respective country representatives.

In order to finally confirm the network as proposed, a detailed review of each station needs to be carried out, including a site visit, in order to assess whether each is suitable for the purposes proposed under the Strategy, and to allow detailed cost estimates to be made.

Three additional sites have been identified that should be considered for the final network. These are at locations where there appears to be a paucity of information that could be of great value for water management in the basin. The costs for these have not been included in the indicative cost estimates for the Monitoring Strategy.

Actions:

- Review the proposed network of hydrologic monitoring stations with regard to suitability for inclusion in the strategic network.
- Upgrade existing stations to be included in the strategic network of hydrologic monitoring stations.
- Install new stations for the strategic network of hydrologic monitoring stations.
- Continuously operate and maintain all stations within the strategic network of hydrologic monitoring stations.

Figure 18: Proposed Strategic Hydrologic Monitoring Network

9.3.2 Establish a strategic network of meteorological monitoring stations (from among stations already existing in the Member Countries' networks) under the auspices of NBI, upgrading the stations as necessary.

As for the hydrologic monitoring network, the strategic meteorological network should be implemented and managed under the auspices of NBI. This will involve the upgrading of some stations presently operated by Member Countries (and perhaps the establishment of

a small number of new stations in strategic locations) to be maintained and operated by the respective Member Countries. Each station should, as a minimum, measure rainfall (including rainfall intensity), temperature, evaporation and humidity). The proposed locations of the stations to be included in the strategic meteorological network are shown in Figure 19 and the stations are listed in Annex 2.

This proposed network, consisting of 38 stations, including one new station, is based on very limited information. However, the selection of stations to be included has been based on the following criteria:

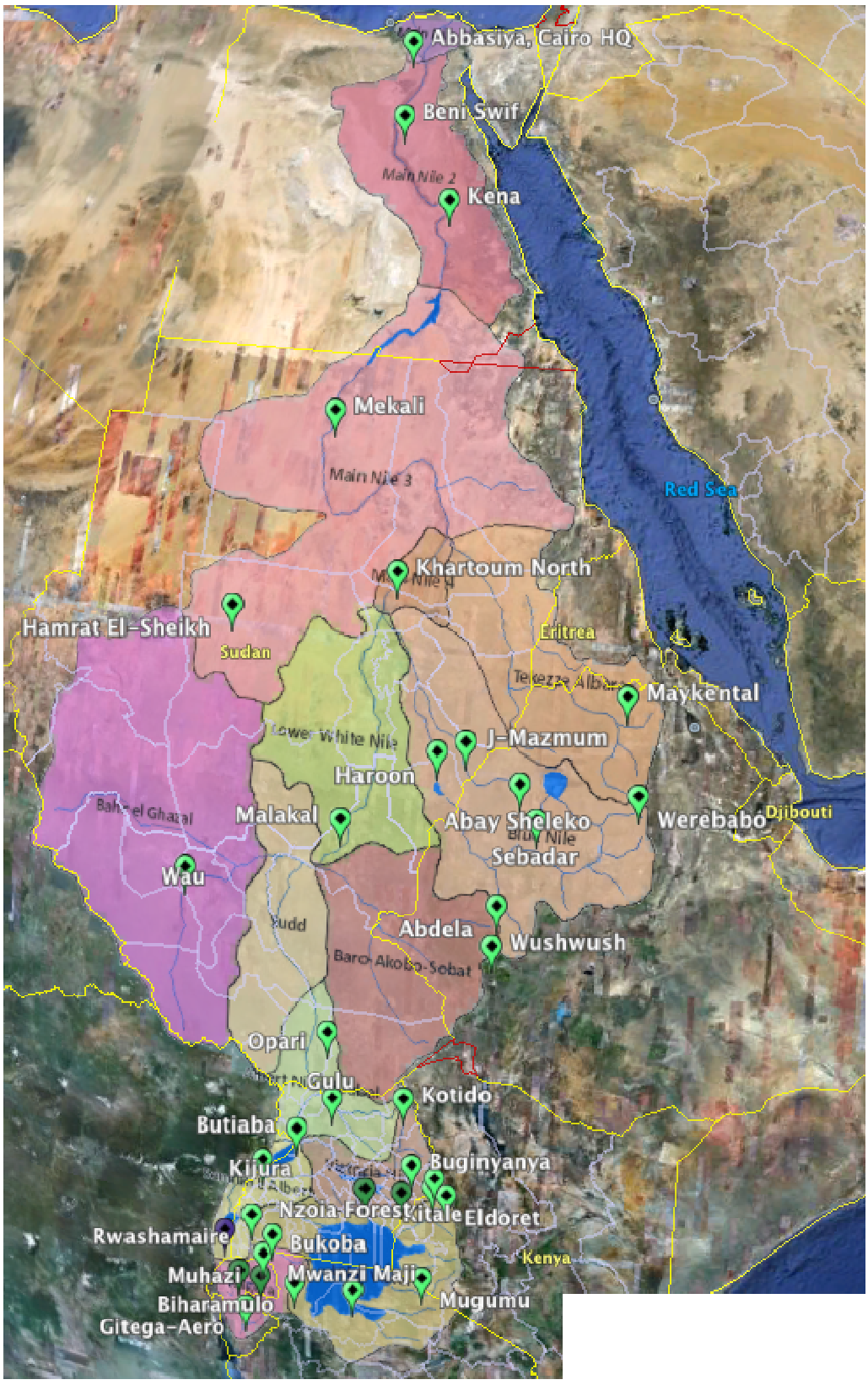
- A broad coverage of the basin, particularly as for virtually the whole basin, meteorological monitoring is deemed to be of very high or extreme importance.
- To have a geographical spread of sites to ensure adequate representation of catchment rainfall patterns and be adequate for catchment modelling.
- Ability to address key water use and related issues, such as irrigation, lake and reservoir water balance, and water for wetlands.
- To include, to the extent possible, existing stations with long periods of historical records and with full meteorological monitoring already (note that from the inventory of existing monitoring stations compiled by NBI from the responses of Member Countries, it is not possible to ascertain the full list of parameters measured or length of record for some stations).
- Stations sited at key locations in the basin that will yield data to be used to compute main stream and tributary flow contributions and for transboundary water management.

Again, in order to finally confirm the network as proposed, a detailed review of each station needs to be carried out, including a site visit, in order to assess whether each is suitable for the purposes proposed under the Strategy.

Actions:

- Review the proposed network of meteorological monitoring stations to confirm suitability for inclusion in the strategic network.
- Upgrade existing stations to be included in the strategic network of meteorological monitoring stations.
- Continuously operate and maintain all stations within the strategic network of meteorological monitoring stations.

Figure 19: Proposed Strategic Meteorological Monitoring Network



9.3.3 Establish a network of water quality monitoring stations under the auspices of NBI.

The strategic water quality monitoring network should be based on the proposals for a transboundary water quality monitoring network for the Nile Basin already developed by the NTEAP Water Quality Monitoring Working Group, as this took some time and effort by a number of water quality specialists to develop. The criteria for selection of water quality monitoring sites has been as follows (adapted from the final report of the Working Group):

- Nature and type of land use activities in the upstream catchments, particularly highly polluting ones.
- Nature and movement patterns of pollutants: are they local or have wider influence? are they short or long lived?
- Adequate accessibility of station for sampling.
- Importance of impact of pollutants to the surrounding environment and community, and in particular urban areas, agricultural areas, aquatic ecosystems and lakes and reservoirs.

In addition, because pollutant *loads*, as well as *concentrations*, are important to monitor, water quality monitoring sites should be chosen close to flow measurement stations (except for lake water quality monitoring sites, where pollutant concentrations are most important). These flow measurement stations do not necessarily have to be those that are included in the strategic hydrologic monitoring network (Figure 18), since that network has been designed for different objectives to the water quality monitoring network. However, flow measurements from the national networks should be available.

The list of recommended stations given in the Working Group's report is somewhat incomplete and has been updated. In addition, because there are overly many stations clustered in the eastern Lake Victoria sub-basin, the total number of monitoring stations there has been slightly reduced.

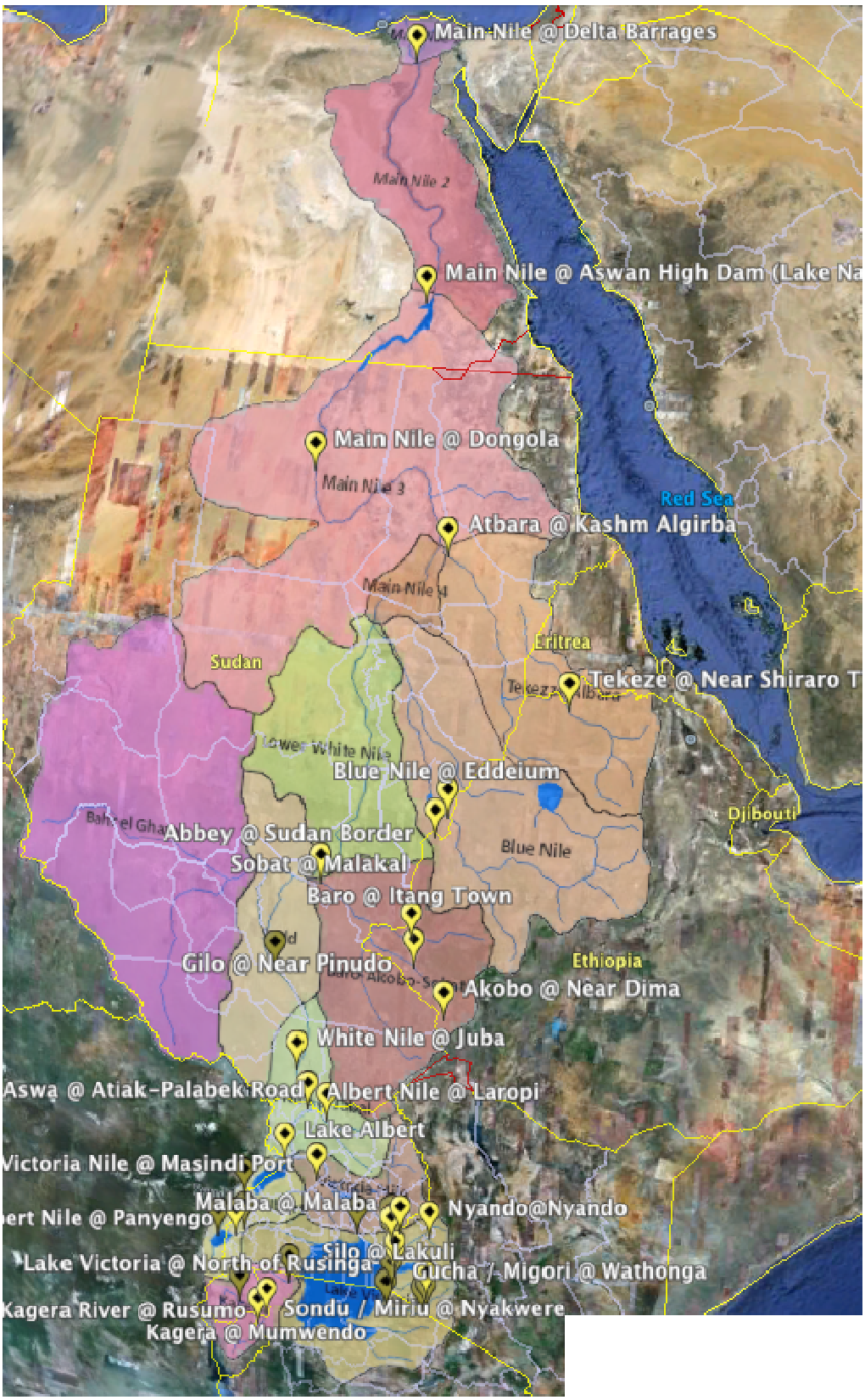
The proposed locations of the stations to be included in the strategic water quality network (44 in all) are shown in Figure 20 and the stations are listed in Annex 3.

It should be stressed that the water quality parameters monitored and the location of the monitoring sites are likely to change over time as development takes place across the basin. Therefore a review of the water quality network should be undertaken at least every five years to ensure that the program is most relevant to address water quality management issues prevailing at the time, or known to be emerging.

Actions:

- Review the proposed network of water quality monitoring stations to confirm suitability for inclusion in the strategic network, and determine which of the "special" parameters are appropriate for monitoring – all stations will be monitored for the "basic" parameters (see Table 3).
- At each site, install instream monitoring equipment for the "basic" parameters.
- For each site, prepare an appropriate sampling program for the "special" parameters and protocols for sample testing.
- Continuously operate and maintain all stations within the strategic network of water quality monitoring stations.
- Periodically review the water quality monitoring network (sites and parameters) to ensure that the program is still relevant and effective.

Figure 20: Proposed Strategic Water Quality Monitoring Network



9.3.4 Ensure that reservoir operators measure and report reservoir levels for inclusion in the NBI Regional Knowledge Base.

Reservoir levels are important to be monitored. This should routinely be done by the organisations that operate the reservoirs (normally the water departments in the Member Countries. There is no need for NBI to become involved in this monitoring. However, under the Strategy it is important that reservoir level data be reported to NBI on a regular and frequent basis for inclusion in the Regional Knowledge Base.

Action:

- Prepare and implement a set of formal agreements with reservoir operators to measure and report reservoirs for inclusion in the NBI Regional Knowledge Base.

9.3.5 Ensure that a program of lake level monitoring is in place and operating effectively.

Levels of the major natural lakes in the basin are already monitored under a variety of programs. Under this Strategy, NBI should review these programs to ensure that this monitoring is comprehensive and effective, and that lake level data be reported to NBI on a regular and frequent basis for inclusion in the Regional Knowledge Base.

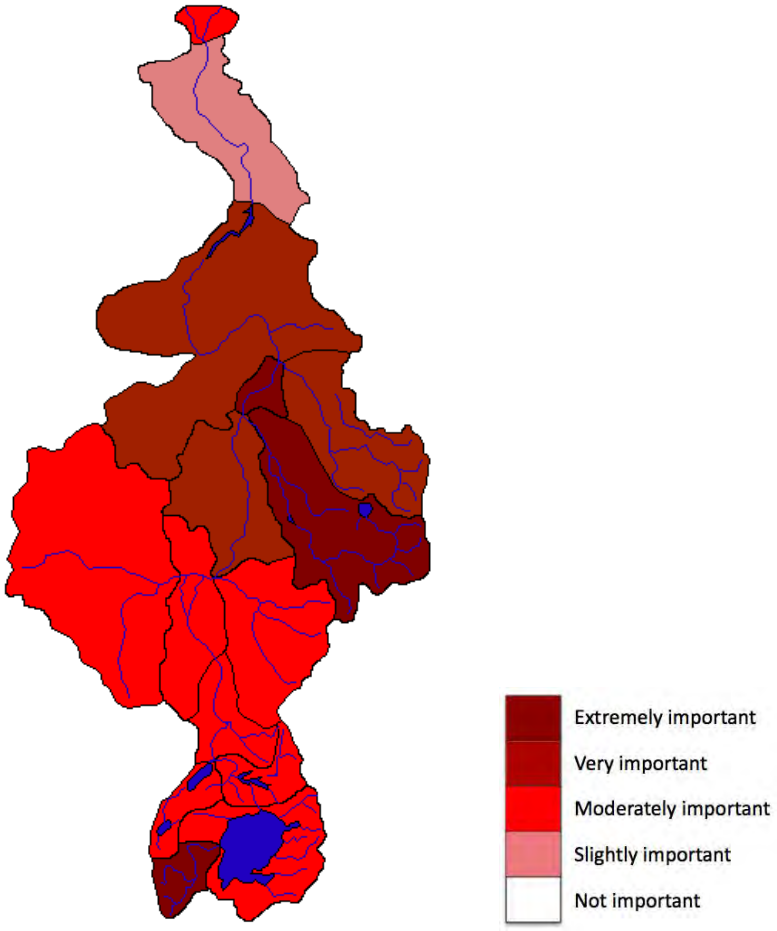
Action:

- Assess the effectiveness of lake level monitoring and assist the relevant Member Countries to upgrade lake level monitoring programs if necessary.

9.3.6 Establish a network of sediment monitoring stations.

Sedimentation is a key water management issue in some parts of the basin, and Figure 21 shows the relative importance of sediment load monitoring across all sub-basins. In deriving this map, the highest ratings were given to those sub-basins where erosion and resulting sediment runoff are significant, and at the same time, this is causing a real problem for water resource development and management.

Figure 21: Relative Importance of Sediment Load Monitoring



The top priority sub-basins are the Blue Nile and the Kagera because in these sub-basins sediment poses a real issue for existing and planned hydropower development. There are also high catchment erosion rates in the Tezere-Atbara sub-basin, but large development projects are not planned there at present. In any case, it has been agreed that, at least initially, sediment load monitoring will be carried out at all of the stations included in the strategic hydrologic monitoring network. This will provide indications of where sedimentation is a potential problem for the future and the incremental cost of sediment sampling at these sites is relatively small.

Action:

- Undertake sediment load monitoring at all sites in the hydrologic monitoring network.

9.3.7 Establish a program of sedimentation (bathymetric) monitoring in selected lakes within the basin

Many of the natural lakes of the basin are subject to sedimentation due to high sediment loads in the rivers that feed them. Lakes such as those in the equatorial lakes region have reduced markedly in both depth and volume over recent decades. A similar situation exists for some of the made-made reservoirs in the basin. However, under the criteria agreed for prioritisation of data needs and inclusion in this Strategy (see Section 5.2), it is considered that the responsibility for sedimentation monitoring for those reservoirs should be the

responsibility of the owners and operators of each of them. However, this means that the natural lakes may be overlooked. It is therefore proposed that a program for sedimentation monitoring be included in the Strategy for selected lakes.

Action:

- Develop and implement a program of bathymetric surveys for sedimentation monitoring for selected lakes, the list to be finalised.

9.3.8 Establish a program of acquisition, processing and interpretation of remotely sensed data to monitor spatial parameters related to watersheds and wetlands.

A number of parameters related to watersheds and wetlands have been identified as of high priority to be monitored. These include catchment erosion, land cover (especially forests) and extent of wetlands (see Table 5). Figure 22 and Figure 23 indicate the identified spatial distribution of the importance of monitoring these parameters. As for the sediment load monitoring (Figure 21), the relative importance of monitoring in each sub-basin has been assessed by considering both the occurrence of the parameters being measured (catchment erosion, land cover and extent of wetlands) and their significance to management of water resources in that sub-basin.

These parameters are spatial in nature and therefore best monitored with the use of remote sensing, specifically from satellites. Many types of satellite imagery are available – at different scale, and using different bands of the electromagnetic spectrum. The type of imagery must best selected to best provide, through image analysis and interpretation, the information related to the parameters of interest. As an example only, it is possible that Landsat *Enhanced Thematic Mapper* imagery may be suitable for the monitoring needs because it has a range of spectral bands (8 in all) with resolution ranging from 15 to 60 metres. Each scene covers 185 x 170 km and is recommended for scales up to 1:100,000.

With suitable ground truthing, it should be possible to estimate the required parameters using this imagery. Otherwise there are a number of other options that could be investigated.

Therefore, before a program of imagery acquisition is commenced, a detailed assessment of the available options must be carried out. While the spatial distribution of catchment monitoring and wetlands monitoring are quite different, when combined it is apparent that most of the basin needs to have satellite imagery for one purpose or another.

Assuming that Landsat imagery proves to be suitable, or a similar suitable alternative is selected, in the vicinity of 150 scenes (depending on overlap and coverage at the basin boundaries) will be required to cover the entire basin. It is recommended that initially coverage of the entire basin be acquired. However, because of the costs and resources required for analysis and interpretation, it is estimated that only around 10% of the basin (where significant issues with regard to catchments and wetlands) will need to be monitored annually (around 15 scenes). A further 20% of the basin may need to be monitored every 5 years and an updated full coverage may only be necessary every 10 years.

Figure 22: Relative Importance of Watershed Monitoring

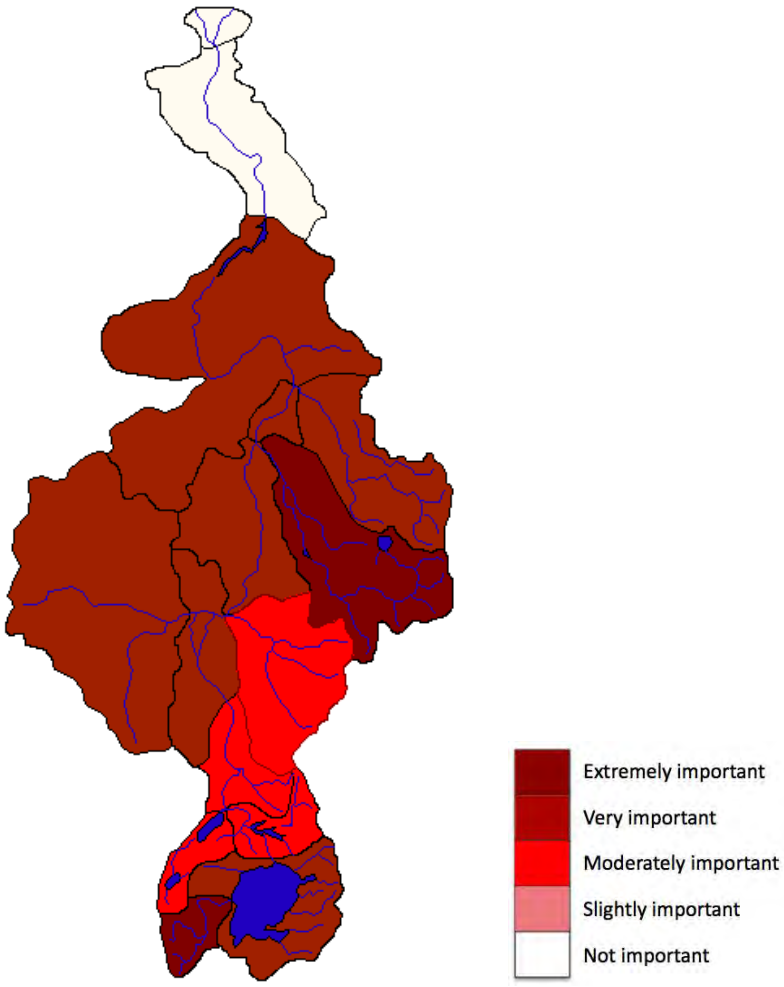
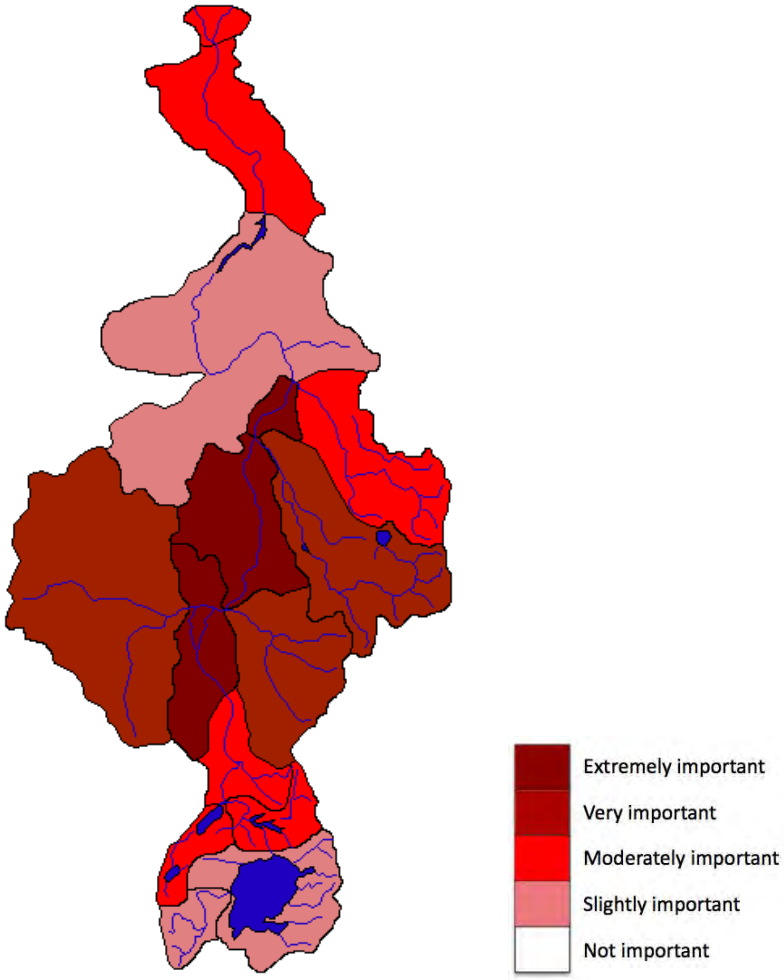


Figure 23: Relative Importance of Wetlands Monitoring



Actions:

- Determine the appropriate scale, spectrum and source of remotely sensed data that will enable the required parameters related to watersheds and wetlands to be measured.
- Prepare guidelines and standards for the interpretation and analysis of remotely sensed imagery for evaluation of relevant watershed and wetlands characteristics and parameters.
- Prioritise sub-basins according to urgency and importance of monitoring needs for catchment and wetlands monitoring and develop a remotely sensed data acquisition program accordingly.
- Acquire, process and interpret data for high priority sub-basins.
- Acquire, process and interpret data for lower priority sub-basins.
- Acquire, process and interpret updated remotely sensed data on a regular basis, depending on priorities.

9.3.9 Choose technology for the strategic monitoring networks that is of the highest standard, consistent with constraints imposed by organisational capacity, availability of funding and logistical practicalities.

In all cases, technologies selected and utilised for implementation of the strategic monitoring networks should be "appropriate" in the sense that they are of the highest technological standard, but consistent with the organisational capacity of the national organisations that must install, operate and maintain them, the availability of funds, and the limitations imposed by the environment in which they will have to operate – often remote and hostile. HYCOS, an integrated satellite telemetry based data acquisition system has already been initially assessed for use in the system. HYCOS (Hydrological Cycle Observing System) is a system promoted by the World Meteorological Organisation (WMO) as part of a world observation system (WHYCOS) program, aimed at improving the basic observation activities, strengthening the international cooperation and promoting free exchange of data in the field of hydrology. It has been implemented in many parts of the world, including in Africa, where parts of the Nile Basin is covered by a number of these systems. The focus of these systems is on integration and in some respects would duplicate what is already proposed under this strategy. However, implementation of HYCOS or some other telemetry/satellite based system should be considered in the medium to long term.

Actions:

- Finalise evaluation of the use of integrated telemetry based data acquisition systems (such as HYCOS).
- Implement the appropriate integrated telemetry based data acquisition system based on the detailed evaluation.
- Maintain and operate the integrated telemetry based data acquisition system based on the detailed evaluation.
- Carefully scrutinise and evaluate proposals for purchase and application of monitoring techniques and equipment to ensure that they are of the highest technological standard, consistent with constraints imposed by organisational capacity, availability of funding and logistical practicalities.

9.3.10 Have an agreed set of environmental (including hydrometeorological) indicators to inform decision makers of basin status and regularly report these indicators.

In order to inform decision makers and to be able to assess status of the basin and important trends, a set of environmental indicators should be adopted for regular reporting, including state-of-the-basin reporting.

The indicators are based on the concept of "stressors", that is, environmental factors that impact on human activity. Initially, it is proposed that four stressor categories be included in the indicator "suite", namely:

- Hydrologic disturbance
- Pollution of waterways
- Ecosystem risk
- Climate change

It has been agreed that these indicators (that also include hydrometeorological indicators) should be as shown in Table 6. However, these indicators should be reviewed to ensure that they are the most effective in representing the status and trend information. The type of indicators to be use may change over time as more and more data is gathered and more water/environmental management issues emerge. For instance, it has been suggested that

certain biological indicators may be useful for management purposes. For instance, indexes of aquatic environmental health have been developed based on monitoring of the diversity of fish species. As already stated, biological monitoring has not been included in the strategic monitoring to be carried out under this Strategy, so such indicators have not been included at this stage. However, it is recommended that this be reviewed in the future.

Table 6: Proposed Environmental and Hydrometeorological Indicators

STRESSOR CATEGORY	INDICATORS	RATIONALE
Hydrologic disturbance	Annual average basin flow	Declining average annual flow (over the long term) indicates increasing stress on the river system from increasing water extractions due to human activity.
	Annual average flow by major sub-basin (*secondary indicator*)	It will be important to assess the trends in flows in the major sub-basins as well as the total outflow from the basin
	Annual total water stored in major reservoirs and lakes	Total water in storage is a measure of the water available for use by humans and the environment. Declining values of this indicator (over the long term) would signal over-extraction of the available water resources.
Pollution of waterways	Average annual salinity	Heightened salinity levels can be the result of seawater intrusion (in the delta) or as a consequence of poor irrigation practices in areas with saline groundwaters.
	Annual maximum BOD	High BOD usually indicates pollution cause by human habitation and poor sanitation. It is most likely to occur near urban centres.
	Average annual total nutrients	While nutrients in water are required to sustain most aquatic species, high levels are an indicator of pollution and can lead to such problems as algal blooms and fish kills. Sources of nutrients (phosphorus and nitrogen) include fertilisers in agricultural areas, and detergents and other domestic waste in urban areas.
	Average annual pesticides	The presence of high levels of pesticides in the waterways usually indicates contamination from agricultural activities where poor practices of pesticide application exist. Irrigated cotton generally uses significant amounts of pesticides.

STRESSOR CATEGORY	INDICATORS	RATIONALE
	Average annual heavy metals	The presence of high levels of heavy metals in the waterways usually indicates contamination from industrial activities, including mining. This indicator should be estimated for areas where such activities take place.
	Average annual hydrocarbons	The presence of high levels of hydrocarbons (oil and grease) in the waterways usually indicates contamination from oil exploration and production activities, such as those in Sudan.
Ecosystem risk	Annual change in extent of wetlands	Decline in wetlands due to reducing water flows and/or land use changes as a result of human activities (such as draining to reclaim land for agriculture) has an impact on ecosystems through the removal of habitat as well as other environmental impacts.
	Annual change in extent of eroded areas	Erosion is generally associated with poor land management and is not only an indicator of watershed degradation, but it also causes downstream sedimentation of lakes and reservoirs, and geomorphological changes in rivers.
	Annual change in extent of forested areas	Deforestation is a major cause of erosion, but also changes the hydrological regime of the watersheds, including increased flash flooding and reduced base flow. If it is widespread, it can also impact on the local microclimate.
Climate change	Average annual temperature	Atmospheric temperature is the most used indicator for climate change.
	Maximum temperature in a year	Changing maximum temperature for each year is an indicator of change (increasing or decreasing) in temperature variability.
	Average annual rainfall over the basin	Average annual rainfall is another widely used indicator of climate change.
	Average rainfall by month (*secondary indicator*)	Differential changes in rainfall for individual months will indicate change in seasonality
	Longest consecutive no rainfall days in a year	The use of average annual rainfall is not sufficient, since most climate change studies predict an increase in rainfall variability. Increases in the longest consecutive no rainfall days in a year would indicate a trend towards more sever droughts.
	Number of	Over time, increases in the number of heavy

STRESSOR CATEGORY	INDICATORS	RATIONALE
	heavy rainfall (>50mm) days in a year	rainfall days in a year would indicate a trend towards more severe flooding.

In Figure 24 a suggested simple format for reporting of the indicators is given. Note that the values shown for the indicators are fictitious and only intended to illustrate the way that the information could be presented. For clarity, three diagrams are proposed: one for the main indicators and one each for the two secondary indicators (annual average flow by major sub-basin and average rainfall by month).

Since many of the indicators will exhibit significant fluctuations from year to year, it is appropriate to compute a 5-year moving average to be plotted on the diagrams, rather than just the value computed each year. This will filter out much of the annual variability and give a much better estimate of the trend. Also, it will be important initially to derive baseline values for each of the indicators from existing information. Estimation of averages for each of the indicators over the period 2000 – 2010 would be appropriate. If this is not possible then a suitable (recent) period of time for the baseline computations should be selected. The scale – that is the "spread" from "Well below average" to "Well above average" – will be generally be different for each individual indicator and will need to be chosen is such a way that it encompasses the range from "very poor" to "excellent".

Figure 24: Format for Reporting of Indicators

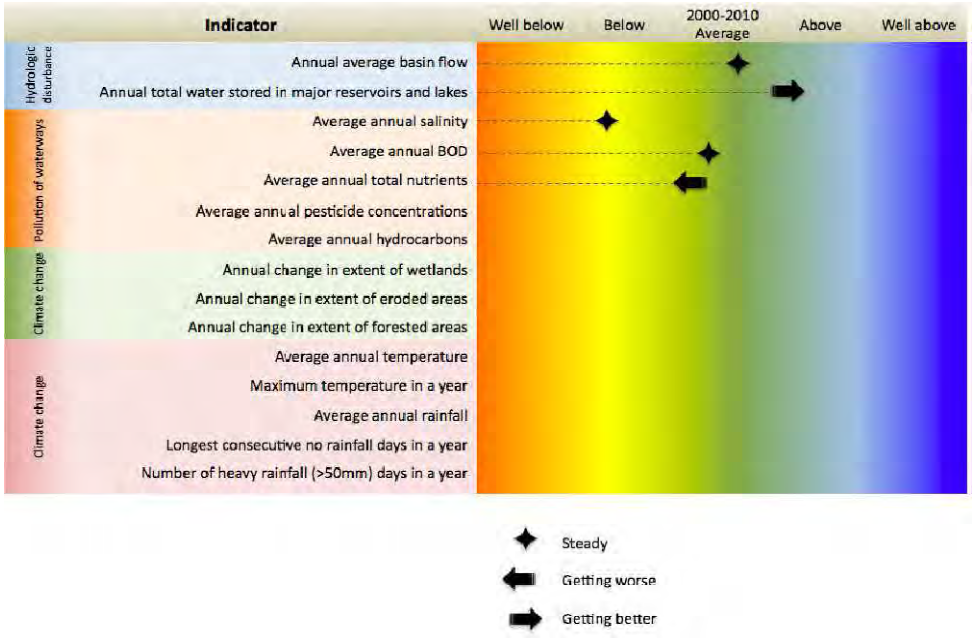
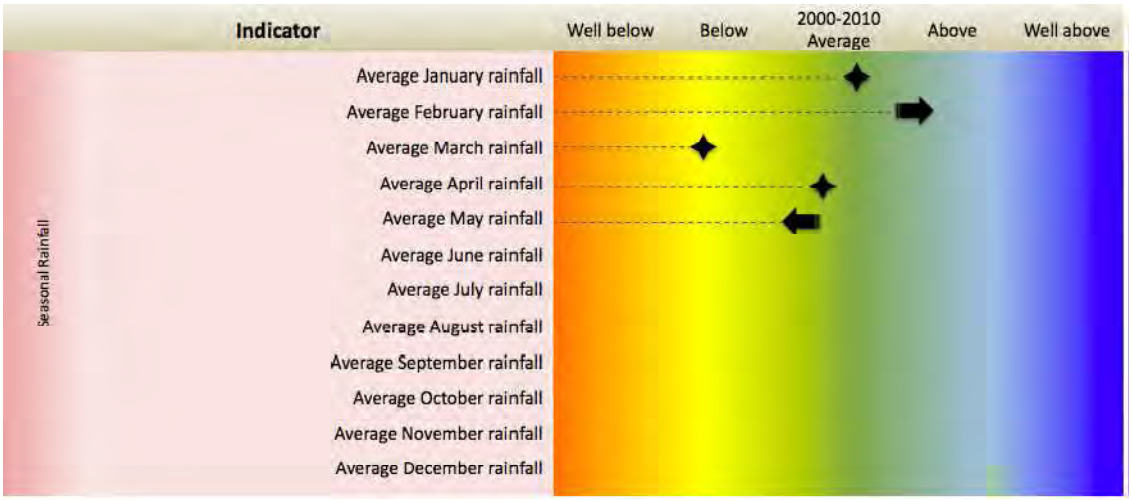
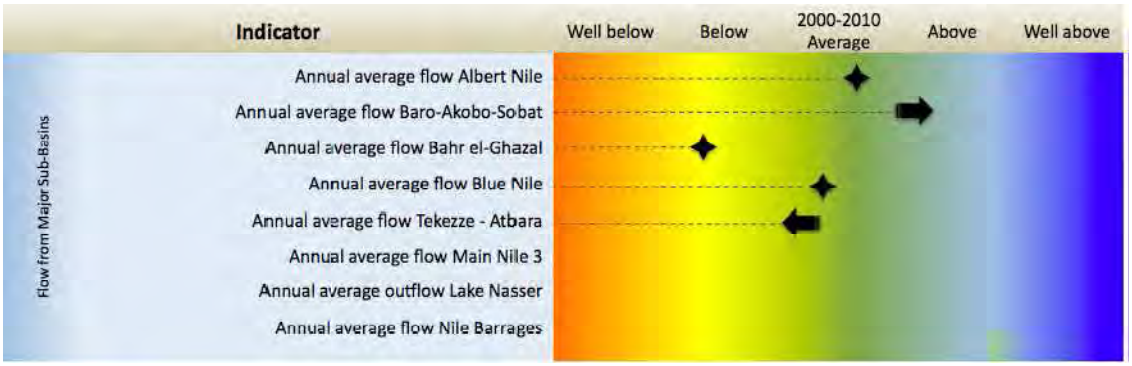


Figure 24 (Continuation)





Actions:

- Review the set of hydrometeorological and environmental indicators proposed (including by consideration of the upcoming "state-of-the-basin" reporting study), as well as the reporting format, and get final approval.
- Determine the stations that will provide the data to compute the indicators.
- Compute a baseline set of indicators from existing data.
- Annually compute and report the hydrometeorological and environmental indicators.
- Periodically review the indicators to ensure ongoing relevance.

9.3.11 Ensure that the data collected under the strategic monitoring programs allow the agreed environmental indicators to be readily computed and in a timely manner.

Clearly it will be important that the data collected over time with the strategic monitoring networks to be established is sufficient to compute the indicators agreed upon. This has been taken into account in the initial design of the proposed networks. However, should it be decided to change the indicator set, then the revised set must be consistent with the data collected.

Action:

- During the review of the proposed strategic networks of monitoring stations make sure that the appropriate data is to be collected.

9.3.12 Ensure that strategic monitoring programs are implemented as a priority, and maintained and operated over the long term, and that key data is used for climate change assessments.

It is of no use having the Monitoring Strategy, and particularly the strategic networks, approved without implementing them and ensuring their operation and appropriate maintenance into the future.

Actions:

- Determine key hydrologic and meteorological monitoring stations (from the strategic networks) to be used for climate change assessment, including for use in the computation of the relevant indicators.
- Ensure continuous operation of the key hydrologic and meteorological monitoring stations.

9.3.13 Ensure that the location of monitoring sites in the strategic monitoring programs to be established under the auspices of NBI allow data to be collected that supports the "technical resolution" of transboundary water (quantity and quality) issues.

This has been taken into account in the initial design of the proposed networks. However, should it be decided to change the design of the networks, then the revised networks must be consistent with this criterion.

Action:

- During the review of the proposed strategic networks of monitoring stations make sure that the appropriate data is to be collected from suitably located sites to support the "technical resolution" of transboundary water (quantity and quality) issues.

9.3.14 Ensure that other available sources of information are monitored (especially the so-called "global knowledge portals" that can provide supplementary information for improved transboundary water management.

There are numerous sites that can provide a variety of socio-economic and environmental information, such as projections of climate change under a variety of different scenarios. These should be "monitored" and used as sources of relevant information when required.

Action:

- Set up and operate a mechanism for regular monitoring of appropriate global knowledge portals for supplementary information relevant to water resource management in the Nile Basin.

10 Key Area 2: Data Archiving and Dissemination

10.1 Rationale

Having monitoring networks in place and operating is only the first step in the process of ensuring that adequate information is available for the various studies, policy development activities, planning and so on, that are required to manage the water resources effectively, sustainably and equitably. Once data has been collected from the field, it needs to be validated and archived according to accepted standards and formats. Furthermore, in order for the data to be useful it must be made accessible to all legitimate users and disseminated to the organisations that require it. This key area covers these activities and while it is not the main focus of the Monitoring Strategy it is nonetheless core to the success of the Strategy as a whole.

10.2 Objectives

The following are the objectives for this Key Area:

1. To ensure that all data collected by NBI projects are (after quality assurance) entered into the NBI Regional Knowledge Base.
2. To ensure that information contained in the Regional Knowledge Base is accessible to those that have legitimate use for it.
3. To provide adequate data to ensure that the DSS can be used as an effective tool for decision making, policy development and program planning.
4. To assist to facilitate greater community participation in decision making related to basin management.

10.3 Sub-strategies and Actions

In order to achieve the objectives in this Key Area, the following strategies are to be adopted.

10.3.1 Continue to implement the existing Interim Data Sharing Agreement and update as necessary, so that all data collected by NBI projects are (after quality assurance) entered into the NBI Regional Knowledge Base.

A significant number of NBI programs and projects collect data as part of their activities. This data is often localised to a particular area of interest and usually short in terms of duration. Nevertheless, such data is valuable and can be a very useful adjunct to long term and strategic monitoring programs, such as those proposed in this Strategy. Interim Data Sharing Procedures have already been developed and agreed to facilitate this. Implementation of the procedures has commenced, and these should be maintained. The procedures should be reviewed at regular intervals and updated to reflect changing circumstances.

Actions:

- Continue to implement the Interim Data Sharing Procedures so that all data collected by NBI projects are (after quality assurance) entered into the NBI Regional Knowledge Base and monitor their effectiveness.
- Review the procedures at regular intervals and update (if necessary) to reflect changing circumstances.

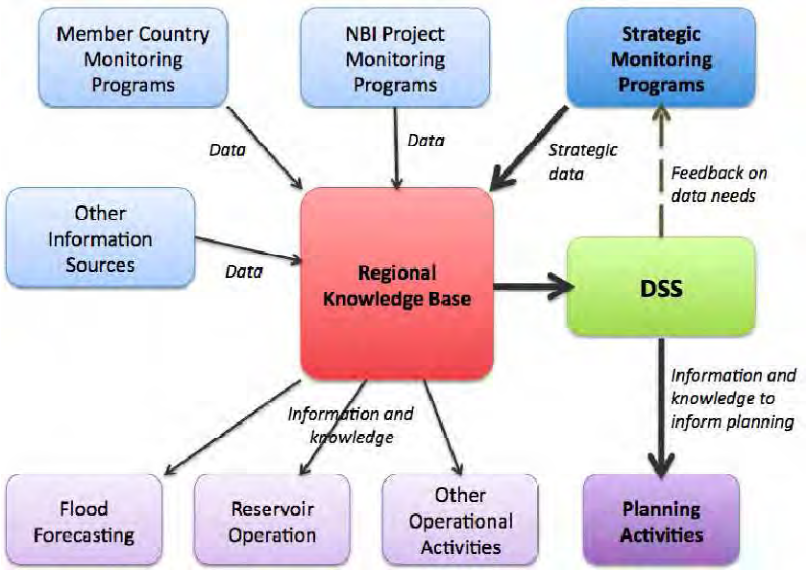
10.3.2 Operate and maintain the strategic monitoring networks effectively and have protocols for the data collected to be entered into the Regional Knowledge Base.

The DSS is presently being developed within the WRPM Project in NBI to provide decision makers in the basin with knowledge and analytical tools to enhance planning and policy development. The monitoring strategy, the Regional Knowledge Base and the DSS form the basic elements that provide information upon which decisions (including policies and plans) can be made and therefore they should "dovetail". The monitoring strategy will provide one critical source of data input to the Regional Knowledge Base. Other data will be gathered from other sources, such as the Member Country monitoring programs, NBI project-specific monitoring, and global knowledge portal sources. However, the DSS will focus on planning of water resources, rather than operational activities, so not all the data from monitoring programs will feed into it (for instance, data for flood warning, reservoir operation and so on).

The DSS, once implemented, should also provide feedback to the monitoring strategy, for instance, where data gaps are identified, so that the strategy (and the strategic monitoring networks) can be continually updated and improved in order to provide the data required.

The linkages between the Monitoring Strategy, the Regional Knowledge Base and the DSS are shown in Figure 25.

Figure 25: Linkages between Monitoring Strategy and DSS



Actions:

- Develop protocols for the data collected from the strategic monitoring networks to be entered into the Regional Knowledge Base (by expansion of the existing Interim Procedures for Data Sharing, or by a separate, specific new agreement).
- Receive strategic network data from Member Countries, process and enter into the Regional Knowledge Base.
- Develop a performance evaluation system based on M&E principles to ensure that data is being collected and archived efficiently and effectively to best-practice standards, and include specific criteria related to provision of data to the Regional Knowledge Base.
- Continuously implement the performance evaluation system, and provide regular reports.

10.3.3 Ensure that mechanisms are in place to allow access to relevant data by community groups (for instance, civil society organisations).

Increasingly, there is a recognition worldwide of the role that can and should be played by the community at large in the management of water resources. In order to be able to participate meaningfully in conservation, planning and management of water resources, people need to have increased awareness and knowledge about the water resources in their area. Civil society organisations often facilitate such awareness raising. However, to do this they need information and so there needs to be mechanisms in place to provide access to relevant water resources information.

Actions:

- Convene a working group to advise on policies for providing access to relevant data by community groups.
- Finalise a policy for providing relevant data by community groups and implement the approved policy.

11 Key Area 3: Quality Assurance

11.1 Rationale

Reliable, consistent and timely data is required for effective planning and decision making for water resource management in the basin. Quality assurance of the data must therefore be a core key area of the Strategy.

11.2 Objectives

The following are the objectives for this Key Area:

1. To have monitoring and data management processes in place that are to international standards, subject to financial and logistical constraints.
2. To produce data and information from the implemented monitoring programs that are reliable, consistent and timely.

11.3 Sub-strategies and Actions

In order to achieve the objectives in this Key Area, the following strategies are to be adopted.

11.3.1 Prepare and implement guidelines and/or procedures for best practice monitoring, applicable to the Nile Basin situation.

Guidelines and formal procedures, based on international standards, but recognising practical constraints that may be imposed by local conditions in the Nile Basin, will be essential to maintain a high quality of data efficacy and consistency from the strategic monitoring networks. NBI should play a lead role in developing these and disseminating them among the Member Countries.

Actions:

- Prepare guidelines and/or procedures for best practice monitoring, applicable to the Nile Basin situation.
- Implement guidelines and/or procedures for best practice monitoring, applicable to the Nile Basin situation.

11.3.2 Ensure that sufficient water quality laboratory facilities are available at appropriate locations across the basin and are producing results that are accurate and consistent.

Water quality analysis, in particular, is often problematic in the achievement of high standards of reliability and consistency in quality-related parameters. Often there can be large discrepancies in the results of water quality tests from laboratory to laboratory. Having a number of reliable, quality-assured laboratories within the basin will be vital to the success of water quality monitoring proposed under this strategy. A laboratory improvement program, aimed at achieving at least one high standard, quality-assured water analysis laboratory in each Member Country was recommended by the NTEAP water quality monitoring strategy. However, due to the high cost of laboratory enhancement, this has so far not been implemented. Also, there is a view that the cost of achieving the recommendations of the water quality monitoring strategy is beyond the capacity of NBI and the Member Countries, and so further work is required in order to develop a more realistic proposal for implementation.

Actions:

- Establish a water quality laboratory working group to review the location, capacity and quality of existing water quality laboratories, and recommend a water quality laboratory improvement program that will satisfy the needs of this Strategy as far as analysis of samples from the strategy water quality monitoring network is concerned.
- Implement the water quality laboratory improvement program as recommended by the working group.

12 Key Area 4: Institutional Development and Capacity Building

12.1 Rationale

The institutional arrangements that are in place for the implementation of the Monitoring Strategy must be appropriate and conducive to efficient and effective monitoring in the field, data management and information dissemination and sharing. Note that in this sense, "institutional" means relating to both the organisations involved (including NBI and the relevant organisations in the Member Countries) and the protocols and mechanisms for interactions among them.

This Key Area also covers training and building of organisational capacity within NBI to be able to implement the Monitoring Strategy effectively.

In addition, for the Monitoring Strategy to be successful, the Member Countries will need to play a major role in its implementation. NBI only has limited resources and in any case, the monitoring will be carried out within the Member Countries' territory – therefore they will have the responsibility and jurisdiction to operate and maintain the strategic networks proposed under this Strategy, as well as implement their own national monitoring programs. However, NBI must play a strong supporting role and facilitate capacity building and achievement of appropriate standards, and assist to find financial support, particularly those countries with scant resources of their own. In addition, coordination among the countries will be vital to successful implementation to ensure consistency of monitoring methods and achievement of high standards of data quality.

12.2 Objectives

The following are the objectives for this Key Area:

1. To have institutional arrangements in place that will facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.
2. To have a dedicated data management group within NBI that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.
3. To have effective coordination of monitoring among member states in their monitoring efforts.
4. For the NBI and relevant agencies in the member states to have the capacity, in terms of human resources, to undertake all activities in the Monitoring Strategy effectively and efficiently.
5. To have staff adequately trained to effectively use the technology available.
6. To have effective and efficient monitoring of key parameters as part of Member Countries' programs.

12.3 Sub-strategies and Actions

In order to achieve the objectives in this Key Area, the following strategies are to be adopted.

12.3.1 Ensure that appropriate institutional arrangements are in place that will facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.

At the present time, certain changes are being proposed for NBI, its mandate and relationship with the Member Countries. Within this context of change, it will be timely to review the arrangements for implementation of the Strategy and to develop and implement

proposed for improvements, not only to the organisations involved (NBI and in Member Countries), but also to the policies and protocols under which they interact.

Actions:

- Review existing and possible future institutional arrangements and develop proposals for enhancements to facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.
- Implement agreed changes to institutional arrangements to facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.

12.3.2 Establish a dedicated data management group within NBI that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.

As NBI will play a pivotal role in guiding and facilitating the implementation of the Monitoring Strategy, its organisational capacity must be strengthened as well as that of its staff involved. A dedicated and permanent data management group should be established within NBI. With changes to the mandate and structure possible in the near future, the opportunity should be taken to establish this group with the framework of the new organisation.

Actions:

- Prepare a proposal for restructuring of NBI to include a dedicated data management group that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.
- Implement the proposal for restructuring of NBI to include a dedicated data management group that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.

12.3.3 Promote effective coordination of monitoring among Member Countries by means of a regional monitoring working group.

Good coordination of monitoring activities among Member Countries will be an important factor in ensuring the success of the Strategy. Such coordination will not take place spontaneously and NBI can play a vital role as the catalyst for improved coordination and facilitate ongoing interactions among the Member Countries within the NBI framework.

Actions:

- Establish a regional monitoring working group.
- Conduct regular meetings of the regional monitoring working group to discuss monitoring issues.
- Implement recommendations of the regional monitoring working group to improve monitoring coordination among Member Countries.

12.3.4 Prepare and implement training courses in all relevant areas of monitoring for involved NBI and Member Country staff.

A series of training courses needs to be developed and implement to bring staff involved with the implementation of the Monitoring Strategy to a high level of understanding and

capability. The course would cover a wide range of topics such as network design, international best practice in monitoring and data management, available technology for monitoring, use of data for modelling and decision support, and so on. Note that these courses are aimed at water management professionals and complement the more technical training to be given to technicians.

Actions:

- Prepare training courses in all relevant areas of monitoring for involved NBI and Member Country staff.
- Implement training courses in all relevant areas of monitoring for involved NBI and Member Country staff.

12.3.5 Ensure that all data monitoring technicians have the understanding and capacity to implement agreed guidelines and procedures

For high quality data to be produced, the knowledge and skills of the technicians that are involved in all aspects of the monitoring and data archiving and dissemination process must be of a high standard. These technicians will, in the main, work in the Member Countries water departments and NBI must take a role, under this Strategy, to ensure that their knowledge and skills are at a level commensurate with the production of high quality data and information to be entered into the Regional Knowledge Base.

Action:

- Undertake necessary training for all data monitoring technicians, both initially and on an ongoing basis.

12.3.6 Ensure that whenever any new technology is introduced into the monitoring programs under this Strategy, adequate training of technicians and other concerned personnel is implemented.

It is clear that any new technology that is to be deployed must be installed, operated and maintained by competent personnel.

Action:

- Prepare and implement training programs as new technologies are introduced into the NBI strategic monitoring programs.

12.3.7 Support Member Countries for development, operation and maintenance of their own national monitoring programs.

As the strategic monitoring networks proposed under this Strategy are necessarily limited in scope, the ongoing nation monitoring programs of the Member Countries will continue to play an essential role in expanding the overall data and information base of the basin. As their capacity is limited to various degrees, NBI must play a support role to assist the countries to improve their own programs and share the information amongst themselves for the benefit of all. This support cannot only be financial, but it can include such activities as capacity development, standards setting, communications and so on.

Actions:

- Prepare a Member Country monitoring support plan, led by the regional monitoring working group, including both financial support and capacity building.
- Implement Member Country monitoring support capacity building plan.
- Implement Member Country monitoring support financial plan.

13 Key Area 5: Financing

13.1 Rationale

Adequate financing of the Monitoring Strategy is obviously a critical factor for its success. However, the Member Countries that will play a key role in implementing the Strategy, through installation, operation and maintenance of the strategic networks, as well as many associated activities, have relatively low capacity to fund this work. Therefore, it will be necessary to seek international support for the implementation of the Strategy, which will become part of the foundation for improved transboundary and in-country water resources management in the Nile Basin.

13.2 Objectives

The following are the objectives for this Key Area:

1. To have adequate funding for the effective implementation of the activities under the Monitoring Strategy.
2. To ensure that Member Countries can mobilise adequate funds for their own monitoring programs to provide data to the Regional Knowledge Base.

13.3 Sub-strategies and Actions

In order to achieve the objectives in this Key Area, the following strategies are to be adopted.

13.3.1 Mobilise funds from international donors and regional economic communities to finance the Monitoring Strategy.

As donor support for the ongoing implementation of the Strategy will be vital, it will be necessary to prepare and present persuasive arguments in order to convince donors to sponsor the various aspects.

Actions:

- Prepare the case for the benefits of funding the NBI's strategic networks (under this Strategy) and present to donors.
- Develop appropriate project "packages" and seek donor funding for these.

13.3.2 Raise awareness of Member Countries about the benefits of increasing their funding for monitoring in their respective territories.

While it is recognised that the Member Countries are relatively poor, their contribution, both financial and in-kind, will be important for the successful implementation of the Strategy. Governments of these countries should be encouraged to see the long-term benefits of the Strategy and, over a period of time, increase their contribution commensurate with their ability to pay.

Action:

- Make presentations to senior government officials of Member Countries and use other means of communication to encourage them increase their funding for monitoring in their respective territories.

13.3.3 Arrange for NBI to fund the cost of capacity building of Member Countries' technical staff to operate the NBI strategic networks.

As part of the cost sharing arrangements, it is proposed that NBI take the financial responsibility for capacity building of Member Countries' technical staff that will be involved in installation, operation and maintenance of the strategic monitoring networks in their own country. This will have "flow-on" benefit by improving effectiveness of national monitoring programs.

Such financing should be ongoing, and therefore will be outside the project activity funding and complementary to it. The source of funding will be the Member contributions to NBI and NBI will coordinate capacity building to gain the maximum benefit.

Action:

- Prepare and implement the necessary agreements between NBI and the Member Countries for NBI to fund the cost of capacity building of Member Countries' technical staff to operate the NBI strategic networks.
- Evaluate the possibility and advisability of offering project subsidies to Member Countries for monitoring outside the strategic networks.

14 Implementation

14.1 Project Orientation

The Nile Monitoring Strategy will be implemented by a project-oriented approach, with most of the required funds being mobilised from international donors and regional economic communities. The tasks to be undertaken under the Strategy will be "packaged" into a number of discrete projects than can then be executed in a phased manner. Recommended project packages have been identified in a broad sense (see below), but much more work will be required to refine these and provide the necessary level of detail so that they can be implemented.

Apart from the project packages, there will necessarily be some tasks of an ongoing nature (such as capacity building of technical staff) that will need to be funded through contributions of Member Countries.

14.2 Assignment of Roles and Responsibilities

14.2.1 Roles and responsibilities of the Nile TAC

The Nile TAC will have overall responsibility for the successful implementation of the Strategy on behalf of the Member Countries. Its roles and responsibilities will include:

- Serving as the guiding and advisory body for the implementation of the Strategy;
- Reviewing information and updates on the status of implementation of the Strategy and providing guidance for improvement.

14.2.2 Roles and responsibilities of the Nile SEC

The roles and responsibilities of the Nile SEC, assisted by the technical arms of NBI, in implementing the Strategy will include:

- Developing and implementing guidelines to facilitate the implementation of the Strategy;
- Preparation and dissemination (to Member Countries) of standards, guidelines and protocols for the sustainable operation and maintenance of the strategic monitoring networks, and the transfer of data to the Regional Knowledge Base;
- Formulating detailed project packages (based on those recommended below) for phased implementation of the Strategy;
- Mobilisation of funds to implement the project packages;
- Procurement of suitable consultants to execute the packages;
- Supervision of consultants in the execution of individual packages;
- Providing leadership in coordination among Member Countries for the effective and efficient implementation of the Strategy;
- Establish and assist the effective operation of the regional monitoring working group;
- Arranging for ongoing training of technical staff of Member Countries to maintain capacity to sustainably operate and maintain the strategic monitoring networks;
- Monitoring and evaluating the overall implementation of the Strategy and providing recommendations for improvement;
- Researching and preparing such reports as may be needed to keep the Nile TAC informed on significant developments, alternative considerations, progress, and ongoing operation of the strategic networks.

14.2.3 Roles and responsibilities of the National Focal Point Institutions

In each of the NBI member countries the Ministry responsible for water affairs has already been nominated as the National Focal Point Institution (NFPI) responsible for all matters relating to the Interim Procedures for Data Sharing relevant to the respective member country. These NFPIs will also take the primary (focal) role for matters related to implementing the Strategy. In this regard, the roles and responsibilities of the NFPIs will include:

- Facilitating the implementation of those activities of the project packages that are to be carried out within their territory. In this regard, the NFPI shall have the responsibilities to engage the appropriate national institution/agency responsible for taking over the monitoring network once established and maintaining the same.
- Ensuring the ongoing operation and maintenance of monitoring stations of the strategic networks that lie with their territory;
- Implementing such standards, guidelines and protocols for the sustainable operation and maintenance of the strategic monitoring stations within their territory, that will be provided by Nile SEC and updated from time to time.
- Participation in the regional monitoring working group;
- Ensuring that technical staff of the respective Member Countries are made available for training in order to maintain capacity to sustainably operate and maintain the strategic monitoring stations within their territory.
- Providing data of a high standard from the strategic monitoring stations within their territory to the Nile SEC in a timely fashion.
- Researching and preparing such reports as may be needed to keep the Nile SEC informed on significant developments, alternative considerations, progress, and ongoing operation of the strategic networks within their territory.

14.3 Implementation Packages

It is proposed that several project packages be designed for implementation of most of the Strategy – all except ongoing routine activities that are not suitable for donor funding. The following sections describe what might be suitable packages, and whether these short be implemented in the short, medium or long term.

14.3.1 Package 1: Program management, institutional strengthening and capacity building

This package would:

- Provide technical and program management support to NBI for the overall implementation of the Monitoring Strategy.
- Assist in the development of proposals for institutional strengthening and capacity development programs.
- Undertake initial capacity building activities.

The duration of the package would be five years, commencing as soon as practicable, when the most resource intensive and complex activities (from a program management perspective) will need to be undertaken. After that time, NBI personnel should be able to continue to manage the implementation process with its own resources.

The specific activities to be included in this package would basically be from Key Areas 4 and 5 and would be:

- Assist with overall coordination of implementation of the Monitoring Strategy.

- Review existing and possible future institutional arrangements and develop proposals for enhancements to facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.
- Prepare a proposal for restructuring of NBI to include a dedicated data management group that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.
- Assist to establish a regional monitoring working group.
- Facilitate regular meetings of the regional monitoring working group to discuss monitoring issues.
- Prepare training courses in all relevant areas of monitoring for involved NBI and Member Country staff.
- Implement training courses in all relevant areas of monitoring for involved NBI and Member Country staff.
- Undertake necessary training for all data monitoring technicians, both initially and on an ongoing basis.
- Prepare and implement training programs as new technologies are introduced into the NBI strategic monitoring programs.
- Prepare a Member Country monitoring support plan, led by the regional monitoring working group, including both financial support and capacity building.
- Prepare the case for the benefits of funding the NBI's strategic networks (under this Strategy) and present to donors.
- Develop appropriate project packages (other than this one) with detailed feasibility studies, costings, and so on.
- Assist NBI to make presentations to senior government officials of Member Countries and use other means of communication to encourage them increase their funding for monitoring in their respective territories.
- Assist to prepare the necessary agreements between NBI and the Member Countries for NBI to fund the cost of capacity building of Member Countries' technical staff to operate the NBI strategic networks.
- Assist to evaluate the possibility and advisability of offering project subsidies to Member Countries for monitoring outside the strategic networks.

14.3.2 Package 2: Establishment of hydrological, meteorological and sediment monitoring strategic networks

This package would:

- Undertake field surveys of proposed hydrological and meteorological monitoring sites and assess conditions.
- Do detailed designs for new stations and upgrading of existing stations, and estimate costs.
- Assist with the technical and logistical tasks of installing the hydrological, meteorological and sediment monitoring strategic networks.
- Provide technical advice on best practice monitoring standards.

The duration of the package would be about three years, and should commence as early as can be achieved. The activities are covered under Key Areas 1 and 3. These activities are:

- Review the proposed network of hydrologic monitoring stations with regard to suitability for inclusion in the strategic network, taking into consideration of the requirements for computing of hydrometeorological and environmental indicators and the need to support the "technical resolution" of transboundary water (quantity and quality) issues.
- Prepare designs for new stations and upgrading of existing stations.
- Upgrade existing stations to be included in the strategic network of hydrologic monitoring stations.
- Install new stations for the strategic network of hydrologic monitoring stations.
- Review the proposed network of meteorological monitoring stations with regard to suitability for inclusion in the strategic network, taking into consideration of the requirements for computing of hydrometeorological and environmental indicators and the need to support the "technical resolution" of transboundary water (quantity and quality) issues.
- Prepare designs for upgrading of existing stations to be included in the strategic network.
- Upgrade existing stations to be included in the strategic network of meteorological monitoring stations.
- Assist with establishing a program of bathymetric surveys for sedimentation monitoring for selected lakes, the list to be finalised.
- Assist to prepare a set of formal agreements with reservoir operators to measure and report reservoirs for inclusion in the NBI knowledge base.
- Assess the effectiveness of lake level monitoring and assist the relevant Member Countries to upgrade lake level monitoring programs if necessary.
- Prepare guidelines and/or procedures for best practice monitoring, applicable to the Nile Basin situation.
- Assist in initial implementation of guidelines and/or procedures for best practice monitoring.

14.3.3 Package 3: Establishment of the water quality strategic network and water quality laboratory improvement

This package would:

- Undertake field surveys of proposed water quality monitoring sites and assess conditions.
- Select equipment and do detailed designs for monitoring stations and estimate costs.
- Assist with the technical and logistical tasks of installing the water quality strategic network.
- Assess existing water quality laboratory facilities in the basin and assist with implementing an improvement program.

The duration of the package would be about four years, and the activities are covered under Key Areas 1 and 3. The activities included in this package are:

- Review the proposed network of water quality monitoring stations to confirm suitability for inclusion in the strategic network, and determine which of the "special" parameters are appropriate for monitoring – all stations will be monitored for the "basic"

parameters. Also, taking into consideration of the requirements for computing of hydrometeorological and environmental indicators and the need to support the "technical resolution" of transboundary water (quantity and quality) issues.

- At each site, install instream monitoring equipment for the "basic" parameters.
- For each site, prepare an appropriate sampling program for the "special" parameters and protocols for sample testing.
- Towards the end of the period, review the water quality monitoring network (sites and parameters) to ensure that the program is still relevant and effective.
- Assist to establish a water quality laboratory working group and provide technical support to review the location, capacity and quality of existing water quality laboratories, and recommend a water quality laboratory improvement program that will satisfy the needs of this Strategy as far as analysis of samples from the strategy water quality monitoring network is concerned.
- Assist to implement the water quality laboratory improvement program as recommended by the working group.

14.3.4 Package 4: Strategic watershed and wetlands monitoring

This package would:

- Provide technical assistance in the achievement of remotely sensed imagery coverage of the Nile Basin at appropriate scale and within the most suitable spectrum.
- Provide assistance in sourcing the appropriate imagery for the required coverage.
- Assist to establish interpretation and analysis procedures to monitor key watershed and wetlands parameters.

The duration of the package would be about one year, and the activities are covered under Key Area 1. The activities included in this package are:

- Determine the appropriate scale, spectrum and source of remotely sensed data that will enable the required parameters related to watersheds and wetlands to be measured.
- Prioritise sub-basins according to urgency and importance of monitoring needs for watersheds and wetlands monitoring and develop a remotely sensed data acquisition program accordingly.
- Assist to acquire, interpret and analyse data for high and lower priority sub-basins as appropriate.

14.3.5 Package 5: Implementation of an integrated telemetry based data acquisition system

This package would:

- Evaluate options for an integrated telemetry based data acquisition system for the Nile Basin to improve the monitoring efficiency of the strategic networks.
- Provide technical assistance in acquiring, installing and the initial operation of the system.

The duration of the package would be about three years, and the activities are covered under Key Area 1. The activities included in this package are:

- Assist to finalise evaluation of the use of integrated telemetry based data acquisition systems (such as HYCOS).
- Assist to implement the appropriate integrated telemetry based data acquisition system based on the detailed evaluation.
- Assist to operate the system for a limited period.

14.3.6 Package 6: Implementation of a reporting system based on hydrometeorological and environmental indicators

This package would assist NBI in establishing hydrometeorological and environmental indicators as a key reporting mechanism for improved water resource management decision making in the Nile Basin.

The duration of the package would be about six months, and the activities are covered under Key Area 1. The activities included in this package are:

- Review the set of hydrometeorological and environmental indicators proposed (including by consideration of the upcoming "state-of-the-basin" reporting study), as well as the reporting format, and assist to get final approval.
- Determine key hydrologic and meteorological monitoring stations (from the strategic networks) to be used for climate change assessment, including for use in the computation of the relevant indicators.
- Compute the hydrometeorological and environmental indicators from existing data to establish a baseline for each indicator.
- Assist to establish a mechanism for annual computation and reporting of the indicators.
- Set up a mechanism for regular monitoring of appropriate global knowledge portals for supplementary information relevant to water resource management in the Nile Basin.

14.3.7 Package 7: Support for data archiving and dissemination

This package would assist NBI in establishing mechanisms for data "flow" to and from the Regional Knowledge Base and the DSS.

The duration of the package would be about six months, and the activities are covered under Key Area 2. The activities included in this package are:

- Review existing data sharing procedures with NBI and recommend improvements as necessary.
- Assist to develop protocols for the data collected from the strategic monitoring networks to be entered into the Regional Knowledge Base (by expansion of the existing Interim Procedures for Data Sharing, or by a separate, specific new agreement).
- Develop a performance evaluation system based on M&E principles to ensure that data is being collected and archived efficiently and effectively to best-practice standards, and include specific criteria related to provision of data to the Regional Knowledge Base.
- Assist to establish a working group to advise on policies for providing access to relevant data by community groups.
- Assist NBI to finalise a policy for providing relevant data by community groups and implement the approved policy.

14.3.8 Package 8: Ongoing activities by NBI and Member Countries

For completeness, an additional package can be defined that would not be implement through external consultancies but rather by NBI and the Member Countries through through own resources. This would be an ongoing package of activities and would include the following:

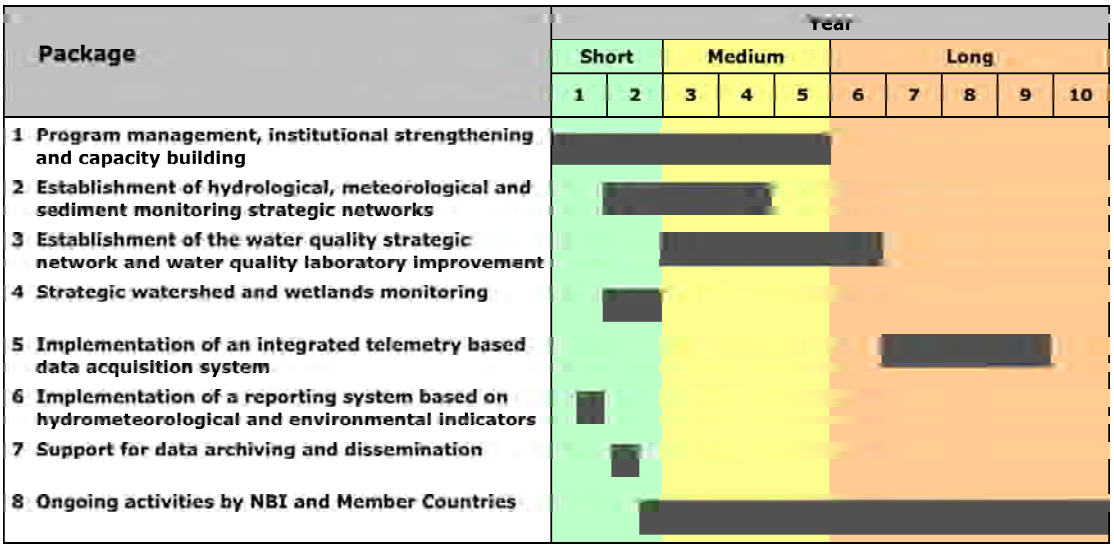
- Continuously operate and maintain all stations within the strategic network of hydrologic monitoring stations.
- Continuously operate and maintain all stations within the strategic network of meteorological monitoring stations.

- Continuously operate (including laboratory analysis) and maintain all stations within the strategic network of water quality monitoring stations.
- Periodically review the water quality monitoring network (sites and parameters) to ensure that the program is still relevant and effective.
- Undertake sediment load monitoring at all sites in the hydrologic monitoring network.
- Acquire and interpret updated remotely sensed data on a regular basis, depending on priorities.
- Carefully scrutinise and evaluate proposals for purchase and application of monitoring techniques and equipment to ensure that they are of the highest technological standard, consistent with constraints imposed by organisational capacity, availability of funding and logistical practicalities.
- Annually compute and report the hydrometeorological and environmental indicators.
- Periodically review the indicators to ensure ongoing relevance.
- Maintain and operate the integrated telemetry based data acquisition system
- Annually compute and report the hydrometeorological and environmental indicators.
- Continue to implement the Interim Data Sharing Procedures so that all data collected by NBI projects are (after quality assurance) entered into the NBI Regional Knowledge Base and monitor their effectiveness.
- Continuously implement the performance evaluation system, and provide regular reports.
- Implement guidelines and/or procedures for best practice monitoring, applicable to the Nile Basin situation.
- Implement agreed changes to institutional arrangements to facilitate the effective and efficient implementation and ongoing operation of the monitoring programs in the Strategy.
- Implement proposals for restructuring of NBI to include a dedicated data management group that can coordinate and manage the operation of the strategic monitoring networks, maintain the NBI Regional Knowledge Base and update the Monitoring Strategy.
- Conduct regular meetings of the regional monitoring working group to discuss monitoring issues.
- Implement recommendations of the regional monitoring working group to improve monitoring coordination among Member Countries.
- Prepare and implement training programs as new technologies are introduced into the NBI strategic monitoring programs.
- Implement Member Country monitoring support capacity building plan.
- Implement Member Country monitoring support financial plan.

14.4 Implementation Timetable

Naturally, not all the actions recommended for the Strategy (and as contained in the proposed packages) can be implemented immediately. A timetable for the implementation of the packages has been prepared, based on the perceived priorities. It is shown in Figure 26.

Figure 26: Implementation Timetable



15 Indicative Cost Estimates

It is only possible to provide indicative cost estimates for the implementation of the strategy. More detailed costings will need to be carried at the time that the strategic networks proposed are reviewed and confirmed (or modified as necessary) and studies to progress other actions in the Strategy are prepared. The bases for the cost estimates are as follows:

15.1 Strategic Hydrologic Monitoring Network

Indicative costs for hydrologic monitoring in the basin are estimated as follows:

- New surface water gauging station installation: The estimated cost for installation of a completely new station using automatic data recorder, including construction of a float well, traveller (for gaugings) and secure equipment shed, is (conservatively) USD 20,000 / station, one-off cost. Of course, the actual costs will vary on a number of factors related to each individual station (location, present condition, type of recorder, and so on).
- Station rehabilitation: For rehabilitation of existing stations including replacement and/or repair of the automatic level recorder, and minor repairs to staff gauges and other related structures, the estimated cost is USD 8,000 / station), one-off cost. Substantial upgrading would be extra.
- Routine operation and maintenance of existing gauging stations: Routine costs are estimated at USD 2,000 / year / station. This figure includes honoraria for the gauge readers (daily readings), and routine visits (every 3 months) from hydrographers (technicians) to collect data from data loggers, carry out gaugings (Ott or ADCP discharge measurements for routine monitoring/verification of the rating curves).

Of the 21 stations proposed for the strategic hydrologic monitoring network, it is not known how many of them will require rehabilitation, nor their actual condition (some may require substantial upgrading). It will require site visits to all proposed stations. Furthermore, review of the proposed network may suggest that one or more new stations be established. The remoteness of the stations from the base of the hydrographers will also influence installation, rehabilitation and operation and maintenance costs. Therefore, an indicative figure of USD 15,000 / station for installation and/or upgrading has been used, and USD 3,000 / station / year for routine ongoing costs.

15.2 Strategic Meteorological Monitoring Network

Indicative costs for meteorological monitoring are estimated as follows:

- New meteorological monitoring station installation: The estimated cost for installation of a completely new station for monitoring rainfall, temperature, humidity and evaporation, using automatic data recorders, including construction of fencing and a secure equipment shed, is USD 10,000 / station, one-off cost, including equipment purchase of USD 5,000 and installation of USD 5,000. Also applicable to upgrading from a daily read rain gauge.
- Station rehabilitation: For rehabilitation of existing stations including repairs of the measuring equipment, and minor repairs to related structures, the estimated cost is USD 5,000 / station), one-off cost.
- Routine operation and maintenance of existing gauging stations: Routine costs are estimated at USD 2,000 / year / station as a minimum. This figure includes honoraria for the rain gauge and evaporation pan readers (daily readings), and routine visits (every 3 months) from technicians to collect data from data loggers.

Again, of the 38 stations proposed for the strategic meteorological monitoring network, it is not known how many of them will require rehabilitation, nor their actual condition (some maybe are presently daily read rain gauges and would require substantial upgrading). It will require site visits to all proposed stations. Furthermore, review of the proposed network may suggest that one or more new stations be established. The remoteness of the stations from the base of the technicians will also influence installation, rehabilitation and operation and maintenance costs. Therefore, an indicative figure of USD 10,000 / station for installation and/or upgrading has been used, and USD 3,000 / station / year for routine ongoing costs.

15.3 Strategic Water Quality Monitoring Network

Costs for water monitoring are more difficult to estimate and will depend on the final network design to be carried out under the strategy (assumed to be around 30 sites). An indicative figure of USD 300,000 for establishment of the network has been adopted, and this includes the purchase of in situ water quality analysis equipment and associated items such as sample bottles, transportation containers and so on. Ongoing costs of operating the network, including sample collection and laboratory costs would be of the order of USD 120,000 / year all up.

15.4 Strategic Sediment Load Monitoring Network

It has been agreed that sediment load monitoring will be carried out at all stations within the strategic hydrologic network, even though the priority for this network should be in the Blue Nile and Tekeze-Atbara sub-basins. A small incremental cost (maximum of USD 2,000 per year) can be expected to be added to the costs of operating and maintaining the flow monitoring stations.

15.5 Strategic Sedimentation Surveys

Sedimentation (bathymetric) surveys have been included in the Strategy for some selected lakes. It will probably be sufficient to carry out such surveys on each lake about every two years. The actual cost will depend on a number of factors, but an indicative cost of $10,000 per lake per survey could be assumed.

15.6 Strategic Remote Sensing

Since there will be a number of options for acquisition of remotely sensed imagery, an indicator cost has been estimated using just one of the options. Around 150 scenes will be required to cover the entire Nile Basin, if Landsat *Enhanced Thematic Mapper* imagery is chosen as source of the remotely sensed data. The present cost of each scene is around USD 600 if the scene is "new" – that is, ordered for a specific area – or USD 280 if the scene is one already archived by the service provider. Accordingly, the cost for total coverage would be between USD 40,000 and USD 90,000, depending on how much archived information is available. Some coverage may already be available to NBI as well. On an optimistic assumption the cost might be about USD 50,000. For scenes to be acquired annually to monitor priority areas, as suggested in the Strategy (10% of total coverage), the cost would be USD 5000 per year, with an additional $10,000 every fifth year.

As additional personnel will need to be employed for the imagery interpretation and analysis tasks (say two technicians) these costs must also be accounted for. A figure of $2000 per person per month plus 25% on costs has been allowed. The cost of an initial training course of 10 days has also been included.

15.7 Other Actions

The other actions proposed in the Strategy will be carried out by consultants, by NBI staff (either existing or to be recruited, and by regional stakeholders through one or more working groups. The costs of these actions have been estimated by considering the amount of work required and knowledge of the costs of similar activities.

15.8 Indicative Cost Stream

Based on the unit costs described above, an indicative annual cost stream for the entire Monitoring Strategy has been prepared. Table 7 shows a summary of costs by Key Area. Table 8 on the other hand shows the annual cost summary by project package.

It can be seen that the total cost of implementing the Monitoring Strategy is about USD 9.56 million over the 10 year time horizon. The costs for the first year will be relatively low as some basic work is undertaken, including the detailed design of the packages. Then, as the establishment of the strategic networks and capacity building take place, the annual costs will rise, with another peak in the longer term with the implementation of the integrated data acquisition system.

As expected, the bulk of the total costs will be for the establishment and operation of the strategic monitoring networks (about USD 5.64 million), of which about USD 1.25 million will be spent on the establishment and operation of an integrated telemetry based data acquisition system.

Annex 4 gives the detailed indicative cost stream required to fully implement the Strategy by action, while **Error! Reference source not found.**Figure 27 summarises this in graphical form.

Table 7: Indicative Monitoring Strategy Costs Summary by Key Area

	KEY AREAS	Costs ($'000)										TOTAL
		Year										
		1	2	3	4	5	6	7	8	9	10	
1	Strategic Monitoring	0	355	500	700	625	375	690	1,025	905	465	5,640
2	Data Archiving and Dissemination	0	130	50	70	70	70	90	70	70	70	690
3	Quality Assurance	0	50	50	500	500	500	0	0	0	0	1,600
4	Institutional Development and Capacity Building	40	190	310	140	40	60	55	15	95	15	960
5	Financing	80	40	20	10	20	0	0	0	0	0	170
	Program Management Support	100	100	100	100	100	0	0	0	0	0	500
	GRAND TOTALS	220	865	1,030	1,520	1,355	1,005	835	1,110	1,070	550	9,560

Table 8: Indicative Monitoring Strategy Costs Summary by Package

	PACKAGES	Costs ($'000)										TOTAL
		Year										
		1	2	3	4	5	6	7	8	9	10	
1	Program management, institutional strenthening and capacity building	210	270	380	190	150	0	0	0	0	0	1,100
2	Establishment of hydrological, meteorological and sediment monitoring strategic networks	0	150	330	190	0	0	0	0	0	0	670
3	Establishment of the water quality strategic network and water quality laboratory improvement	0	0	80	780	730	500	0	0	0	0	2,090
4	Strategic watershed and wetlands monitoring	0	105	0	0	0	0	0	0	0	0	105
5	Implementation of an integrated telemetry based data acquisition system	0	0	0	0	0	0	250	600	400	0	1,250
6	Implementation of a reporting system based on hydrometeorological and environmental indicators	0	110	0	0	0	0	0	0	0	0	110
7	Support for data archiving and dissemination	0	130	0	0	0	0	0	0	0	0	130
8	Ongoing activities by NBI and Member Countries	10	100	340	360	475	505	585	510	670	550	4,105
	GRAND TOTALS	220	865	1,030	1,520	1,355	1,005	835	1,110	1,070	550	9,568

Figure 27: Indicative Cost Stream

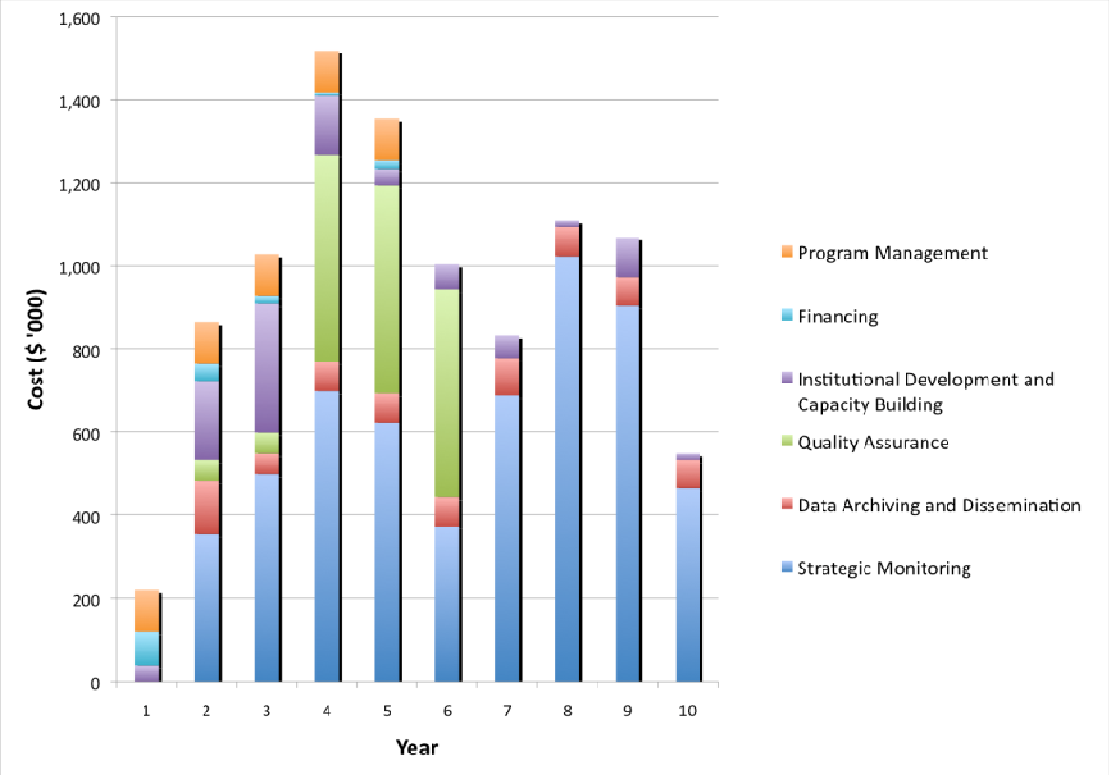


Photo: Shutterstock

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