NEEDS ASSESSMENT AND CONCEPTUAL DESIGN OF THE NILE BASIN DECISION SUPPORT SYSTEM CONSULTANCY

NILE BASIN DECISION SUPPORT SYSTEM

FINAL INCEPTION REPORT

ANNEX A: Situation Assessment Report

Vienna/Austria, Addis Ababa/Ethiopia, 27 November 2007

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

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NEEDS ASSESSMENT AND CONCEPTUAL DESIGN OF THE NILE BASIN DECISION SUPPORT SYSTEM CONSULTANCY

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1 Data Sources

Before proceeding, it is important for the reader to note that data sources were not in every case consistent, accurate or current. Different values for the same parameter were repeatedly encountered in the source documents, sometimes even in the same document or in documents emanating from the same agency. To the greatest extent possible such shortcomings have been dealt with on the basis of advice kindly provided by reviewers of the Draft IR or from learned participants at the 1st Regional Workshop – but even these could not always agree.

The difficulty was acknowledged by the participants to the workshop however. Accordingly, it was suggested that the Consultant might continue to welcome corrections and clarifications to (especially quantitative) data an information until the end of the Analysis Phase of the study.

The following text nonetheless represents the consultants best efforts to utilise whatever updated and corrected information had been made available by the time of writing, but even so, the reader's cooperation and advice is eagerly invited in the event that errors and shortcomings remain.

2 Physiographic information)

It is considered best practice in modern water management to manage the resource on the basis of hydrological or hydraulic rather than political or civil-administrative boundaries, in other words by basin ro sub-basin. Enquiries made during the early stages of this Inception Phase confirmed that the Nile Basin had yet to be sub-divided into an agreed set of sub-basins. Consistent with best practice therefore and in order to institutionalise a sub-basin structure for the DSS from the outset, the consultants therefore took it upon themselves to suggest an appropriate sub-basin delineation and propose it to the Client for discussion and approval. The result, which has already been shared with the Client pending formal comments, is presented as Figure 2.1 and described below. It was developed from two maps prepared by UNEP and from sub-divisions already suggested for the Eastern Nile by ENSAP.

Fifteen sub-basins are proposed and have been provisionally named. As can be seen from Figure 2.1 some of the sub-basins comprise the catchments of major tributaries rivers while others comprise reaches of the Nile itself as it flows between confluences with these tributaries or between signficant hydrological features such as the Aswan High Dam and the Main Nile 1. Each sub-basin is described briefly in the sub-sections below, while Figure 2.2 is a schematic illustrating the relationship between signficant subsidiary rivers, national boundaries and the proposed sub-basins; and Figure 2.3 (FAO 2006) provides an indication of the relative importance of the side catchments on annual river flows. It provides a clear indication of the losses that occur due to evaporation from the Sudd wetlands. It also clearly shows that by far the greatest contribution to the Nile flow orginates in the Southern and Eastern portions of the basin, where altitudes tend to be higher, especially in the east, and where almost all of the basin's rainfall occurs, albeit on a seasonal basis (Figure 2.4 refers).

The sub-basins are described in more detail, especially in terms of climate and water availability in Chapter 6, and in terms of water use patterns and infrastructure in Chapter 9.

Figure 2.1. Proposed Delineation of Nile Sub-Basins

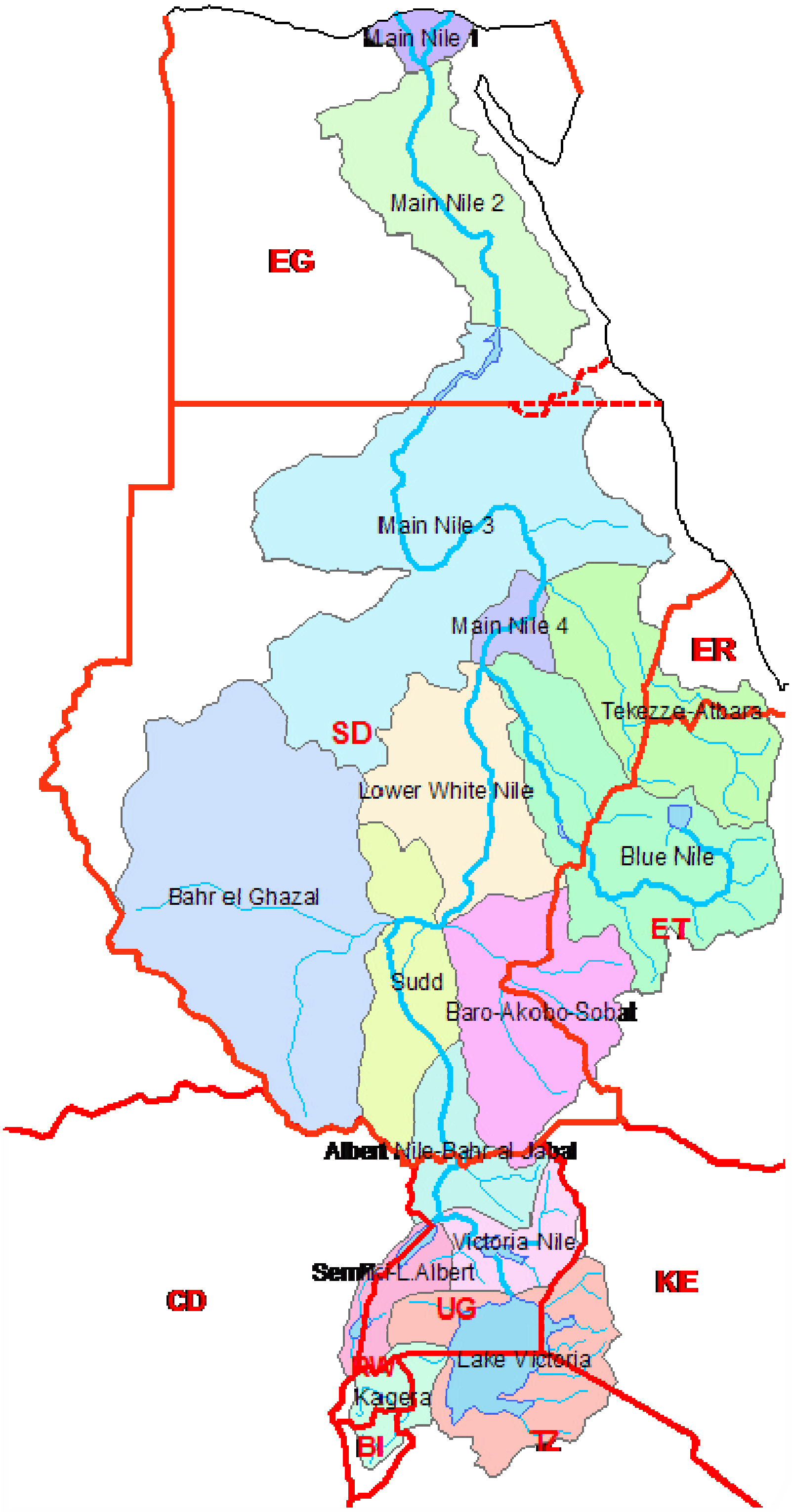


Figure 2.2 Main Tributaries by Sub-Basin

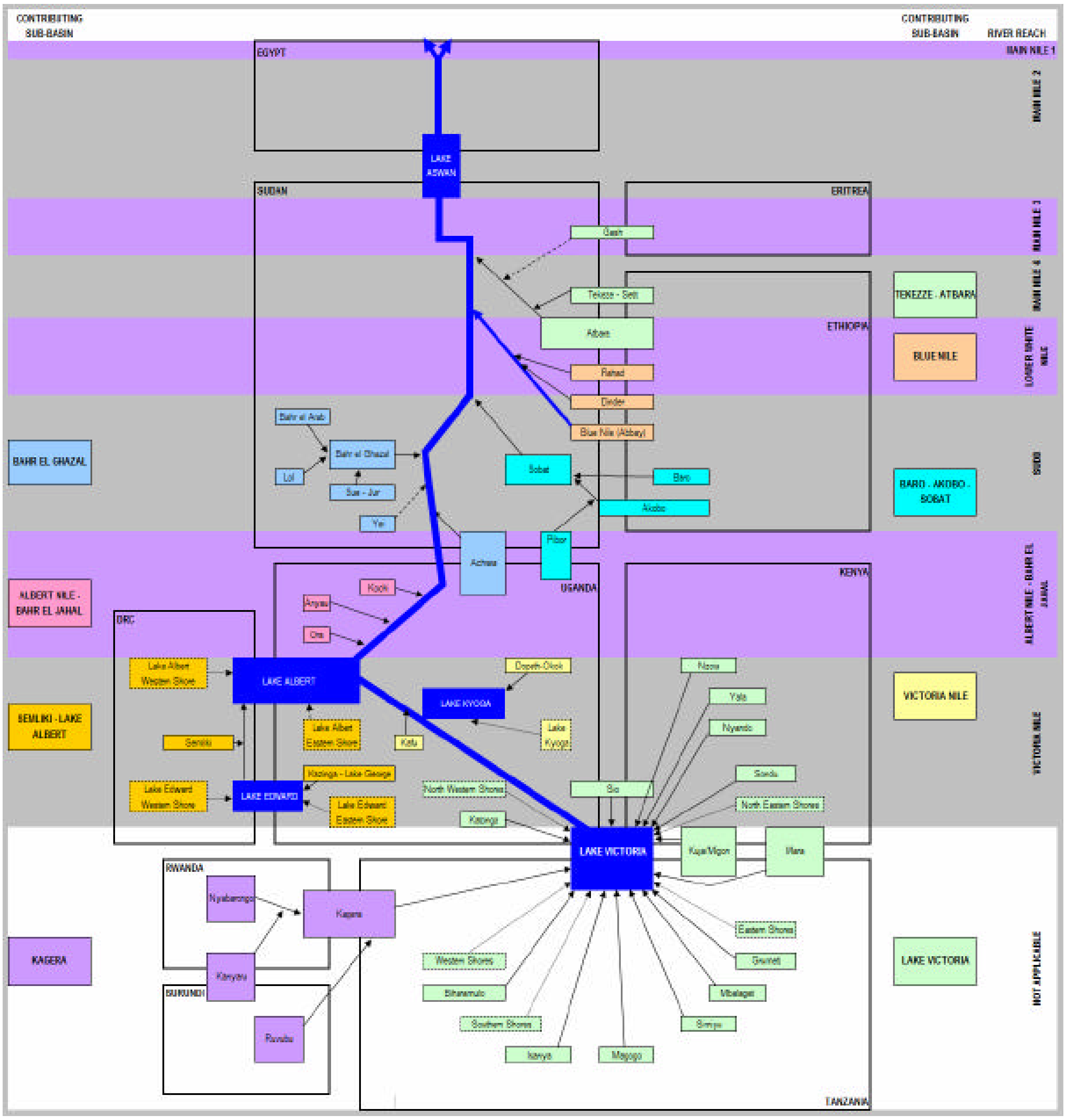


Figure 2.3

Relative Importance of the Side Catchments

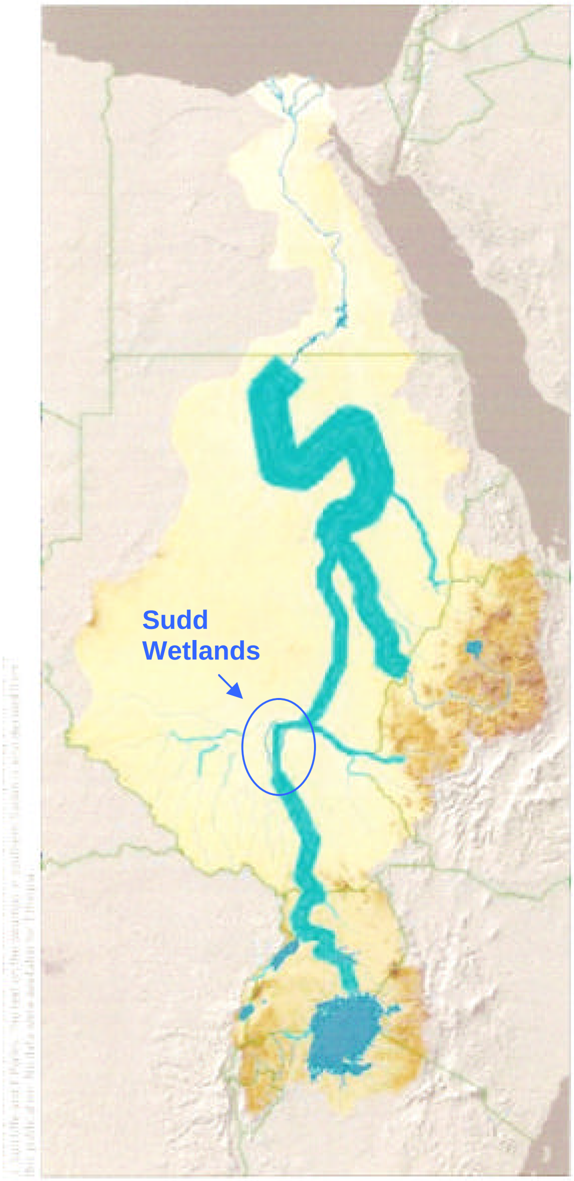
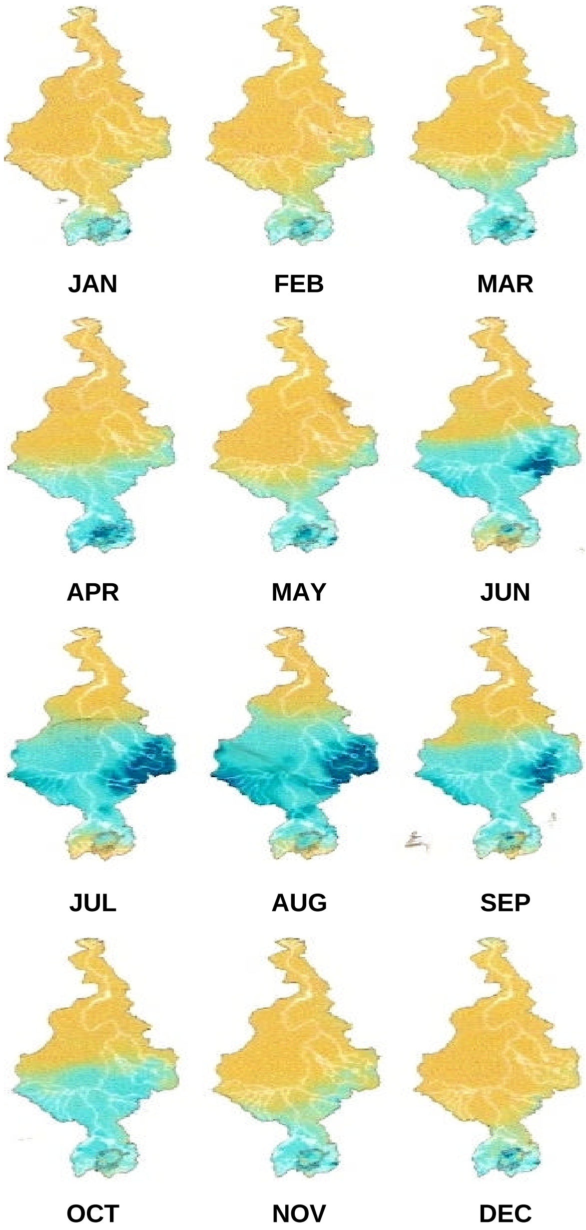


Figure 2.4

Seasonal Rainfall Coverage



Source for both figures: FAO 2006

3 Socio-economic aspects

3.1 Demography and Society

Given the large number of countries, the reach of the basin across Africa, as well as the range of agro-ecological zones, the human geography of the Nile basin is extremely diverse. The nine states that comprise the basin cover some 300 million people, of which about 150 million live within the Nile Basin itself. Some of Africa's major cities, like Kampala, Khartoum and Cairo, are located in the basin, of which the latter alone accounts for around 10 percent of the basin's total population.

In human population terms the countries vary hugely, from above 60 million in each Egypt and Ethiopia to under 10 million in Rwanda and Burundi. The population growth in the riparian country varies with the economic development level: being high in the predominantly agricultural economies and declining for the industrializing economies. A similar trend is observed for the urbanization rate, which increases with the economic development.

The population density varies widely for the upstream and downstream sub-basins. In the upland sub-basins the population density varies from 250 to 500 inhabitants per square kilometres. In the downstream sub-basins the population density is low if calculated for the surface area. However if the population density is calculated per cultivated area, it rises drastically since the desert area is excluded. For example, the population density is 1700 inhabitants/km2 for the 5% of the total area of Egypt that is cultivated.

Table 3.1 Demographic developments in the Nile Basin

Country	Population *1	Surface area *2	Population density *3	Population in rural area (%)	Population in Nile Basin (%)	Population growth (%)
Uganda	27.2	241	111	88	90	2.8
Tanzania	37.7	945.1	40	63	10	2
Sudan	39.4	2,505.8	12	60	79	2.2
Rwanda	8.5	26.3	345	80	80	3.2
Kenya	32.4	580.4	56	59	37	2.2
Ethiopia	75	1,104.3	68	83	39	2
Egypt	77	1,001.5	76.8	58	95	1.8
DR Congo	54.2	2,344.9	23	68	7	3
Burundi	7	27,8	265	90	55	2.9

*1 in millions, *2 in thousand square kilometres (1997), *3 heads per square kilometre (1997)

The total population of Uganda is estimated at 26.7 million (2004) of which 88% is rural. The annual population growth rate is 2.8%. The national population density is 111 inhabitant/km2, with a range from 8 to 157 persons/km2 for different provinces. About 90% of the population lives in the Nile Basin.

The total population of Tanzania is 37.7 million (2004) of which 63% lives in the rural area. The population density is 40 inhabitants/km2 and the population growth is estimated at 2%. Around 10 % of the population lives in the Nile Basin and latest census (2007) shows that the population density varies between 55 and 150 persons/km2 in the basin and the population growth of around 3%.

Sudan's population is 34.2 million (2004) with an annual growth rate of 2.2 percent. Population density is 14 inhabitants/km2 and 60 percent of the total population is rural. About 79% of the population lives along the Nile and its tributaries.

Rwanda's population was estimated to 8.5 million in 2004 of which 80% is rural. The annual population growth rate is estimated at 3.2%. Rwanda's population density has risen from 183 inhabitants/km2 in 1981 to 315 per km2 in 2002.

The total population of Kenya was estimated at 32.4 million (2004) of which 59 percent lives in the rural areas. In 2007 the annual population growth rate was estimated at 2.2 percent. The average population density is 56 inhabitants/km2 but is 329 inhabitants/km2 for the territory located inside the Nile Basin.

The total population of Ethiopia is estimated at 75 million (2006) of which 83% lives in the rural area. The population density is 68 inhabitant/km2 and the population growth is estimated at 2%. About 39% of the population of Ethiopia is living in the Nile River basin.

The population of Egypt is estimated to be 77 million in 2007 of which 58% lives in the rural area. Egypt's population density is estimated at 76.8 inhabitants/km2 but for the inhabited area (5% of the territory) it is around 1.900 persons/km2. More than 95% of the Egyptian population lives in the Nile basin.

The population of DR Congo was estimated at 54.2 million in 2004 of which 68% lives in the rural area. DR Congo's population density is estimated at 23 inhabiltants/km2. The annual population growth lays around 2.9 percent.

Burundi's population was estimated at seven million inhabitants in 2004, of which 90% lives in the rural area. The population density varies between 254 to around 500 inhabitants per km2. The annual population growth lays around 3 percent.

Demographic developments create pressures on the national resources in the riparian countries. In the upstream agricultural economies it results in fragmentation of the agricultural holdings and encroachments into the forests and nature reserves. In the Lower Nile Basin the economy is diversifying and the service and industrial sectors are expanding and absorbing the excess labour force of the rural economies.

The rich human geography in the Nile is characterized by ethnic, religious, and cultural diversity, cutting across national as well as basin boundaries with neighbouring river basins. Many riparian states have great diversity: Ethiopia alone has over fifty ethnical groups and is roughly split between Muslim and Christian population.

Equally important as ethnicity is the range of livelihoods associated with the demographic characteristics of the basin. For many populations within the basin, subsistence production is the mainstay of their survival, whether through pastoral livestock production in the lowlands of Sudan and Ethiopia, or the highland agriculture in countries like Rwanda, Burundi and Kenya, or irrigated agriculture in the lowlands of Sudan and Egypt In many riparian stated these livelihoods are linked to particular ethnic and/or religious identities. The increased competition for natural resources between the pastoral and traditional agricultural livelihoods, will easily leads to environmental degradations. This can easily lead to social tensions that have immediately an ethnical dimension.

3.2 Administrative Structrures and Socio-economics

The ethnical identities have influenced the administrative structures in the riparian states. Some countries have a federal administrative structure with sub-national states that govern territories formed along ethnical boundaries, like Ethiopia and Sudan. Other riparian states have a centralized administrative structure with sub-national governorates or provinces. The administrative structures also effects the water resources management, which increasingly will take place on basin level. Changes in the decisions structure for water resources management can therefore have important socio-economic as well as political consequences for the relations between federal, sub-national states and ethnical groups.

Table 3.2 Key features of the Public Administration organization structure of riparian states

Members	Central government	State governments	Regional government	Local government
Burundi	Central State		17 Provinces and 1 city administration	Districts
DR Congo	Central State		11 provinces including Kinshasa	Districts
Egypt	Central State		27 Governorates	Districts and municipalities
Ethiopia	Federal State	9 Regional states and 2 autonomous city administrations	(Zonal Offices)	Districts (Woheda)
Kenya	Central State		Provinces	Districts and municipalities
Rwanda	Central State		Provinces	Districts
Sudan	Federal State	25 States	Provinces	Districts and municipalities
Tanzania	Union State	2 Governments	26 Regions	Districts and municipalities
Uganda	Central State			Districts and municipalities

Ethiopia, Tanzania and Sudan have a federal administrative structure in which the regional governments have a wide autonomy. Tanzania is a union state having two governments. In Ethiopia and Tanzania an administrative reform process is taking place where operational responsibilities are being delegated to the local government authorities. The other riparian stateshave an administrative structure with a national, provincial and district administrative levels. In all these members states attempts are made for delegation of operational responsibilities to the local government authorities.

For decision makers and managers the ethnical and administrative layers adds to the complexity to the ways in which trans-boundary initiatives will develop and implement projects based on the equitable sharing of benefits between states and ethnic groups.

Given the human heterogeneity of the basin, the achievements of a socially stable politically benign environment for river basin development will always be challenging. However there are important ways in which the development of benefits from the river's water can form a positive feedback loop, assisting national development processes in adding advantage to deprived regions, increasing successful national integration and economic development, and eventually broadening the elimination of poverty within the basin.

3.3 Socio-Economic development

The historical development of the Nile Basin has left a legacy of cultures and societies with rich archaeological and cultural records. The human geography of the Nile Basin is extremely diverse given the large number of countries, the reach of the basin and the wide range of agro-ecological zones. The nine states that comprise the Nile Basin have some 300 million inhabitants of which about 50% live within the basin itself. The great ethnic, cultural and religious diversity, cutting across national as well as basin boundaries, creates opportunities but also threads for socio-economic development in the Nile Basin.

The hydrological and geographical variability of the Nile Basin are matched by socio-economic differences between the riparian countries. Egypt's economy dwarfs all the other economies with an industrializing economy with average income levels that amount to US$ 1,490- per capita. The other countries are predominantly agricultural economies with 80-90 % of the labour forces still involved in the agricultural sector and with incomes levels that vary between -US$100 and 360- per capita. There is an urgent need to create a more equitable development, for which economic growth and collaboration within the basin are preconditions.

Table 3.3 Key Socio-economic characteristics of riparian countries in the Nile Basin

Members	% in agricultural sector	GDP per capita (US$)	% Economic Growth	Domestic water supply coverage Rural	Domestic water supply coverage Urban
Burundi	80-90	110		61	96
DR Congo	70-75	697		26	89
Egypt	42	4300	6.9	94	96
Ethiopia*	81	430	7.1	11	81
Kenya	80-90	512	6.2	31	87
Ruanda	90	250		61	64
Sudan	57	519	8	64	78
Tanzania	79	280	5.6	62	92
Uganda*	78	310		52	87

Source FAO Aquastat 2005 except for Rwanda: Enquente Intégrée sue les Conditions des Vies des ménages (EICV 1 and 2)

The significance of agricultural sector varies widely between the Nile Riparian States. The labour force engaged in the agriculture constitutes 80 to 90 percent of the workforce in the Equatorial Plateau and East African countries. This drops to between 70 and 75 percent in DR Congo and Sudan, and to 42 percent in Egypt.

The agricultural sector of Burundi provides occupation to more than 90% of the economically active population. The sector generates more than 49% to the GDP, 95% of food supply and 95% of the foreign earnings through export. However, the sector is dominated by subsistence agriculture that is practised by about 1.2 millions households who cultivate at average only 0.5 ha. The proportion of the population living under the poverty line has varied during the past decennium between 35 and 58 percent. In 2002 61 percent of the rural population and 96% of the urban population were using improved drinking water sources.

3.3.1 Egypt

Egypt has a diversifying economy with the agricultural, industrial and services sectors contributing respectively 17%, 32%, 51% to the GDP. The GDP per capita is 4300 US$ and the GDP growth rate was 6.9% in 2006. The major exported commodities are: petroleum, textiles and cotton, fruits and vegetables and manufactured goods. Still 20% of the households live under the poverty line and these are mainly involved in subsistence agriculture in rural Egypt. The drinking water supply is quickly developing, covering about 94% of the rural and 96% of the urban population.

3.3.2 Ethiopia

Ethiopia is one of the poorest economies in the world where the economic as well as the social indicators show that the country is severely impoverished. GNP per capita still stands at around USD$110 and about 44 percent of its population lives below the poverty line. The Ethiopian economy is fundamentally rural and relies heavily on the agriculture sector, which contributes to nearly half of the GDP, 85 percent of export and 85 percent of total employment. But agriculture in Ethiopia is dominated by small-scale farmers who are responsible for 95 percent of the cultivated land, mainly for subsistence needs. Household vulnerability to external shocks is extremely high. In 2002 11 percent of the rural population and 81% of the urban population were using improved drinking water sources.

3.3.3 Kenya

In Kenya agriculture is still the main sector of Kenya's economy and the sector greatly influences the economic performance of the country. In 2006, the GDP was estimated at US$ 512 per capita. The annual economic growth was that 6.2 percent in 2007. About 74 percent of the economically active population is engaged in the agricultural sector, which contributed 16.6 percent to the GDP. About 80% of them are smallholders and they are mainly practicing subsistence farming. A substantial percent of them have marginal holdings and are living under the poverty line. Improved water resources were in 2002 accessible for 62% of the population, ranging from 89 percent in urban areas to 46 percent in rural areas. Improved sanitation facilities are used by 56 percent of the urban population and 43% of the rural population.

3.3.4 Sudan

Although endowed with rich natural resources, Sudan remains comparatively underdeveloped as a result of civil unrest. The GDP of the Sudan is growing steady and annual growth rates increased from 5.1% in 2003 to 8% in 2006.. The agricultural sector used to be the most dominant in the country's economy, even though its share has declined recently because of decreased agricultural production and the increased exploitation and export of mineral oil. The sector contributed over 39 percent to the GDP and employed 57% of the economically active population in 2004. Poverty in the Sudan is a massive and predominantly rural phenomenon. Between 50 and 70 percent of the population, who predominantly live in the rural area, are estimated to live under the poverty line. In 2002 78 percent of the urban population and 64 percent of the rural population had access to improved drinking water sources.

3.3.5 Tanzania

In Tanzania 79 percent of the economically active population is active in the agricultural sector and they produce 43.4 percent of the GDP. The agricultural sector continues to lead economic growth, in spite of the recent emergence of high-growth sectors of mining and tourism. The annual economic growth is steady increasing and was assessed at 5.6% in 2006. The national poverty rate is about 36 percent and is concentrated in the rural areas. In 2002, 92 percent of the urban and 62% of the rural population were using improved drinking water sources.

3.3.6 Uganda

The GDP of Uganda was US$ 6.2 billion and the value added by agriculture was 33.1%. In Uganda agriculture provides occupation to 78% of the total Economically active population. The proportion of people living below the poverty line in Uganda has decrease during recent years and was 31 percent in 2005/06. Poverty has decreased by 43% of the urban areas and only 16% in the rural areas. These rural households get their earnings from subsistence farming and are vulnerable for external shocks like drought, floods, and death of a family member. In 2002 52 percent of the rural population and 87% of the urban population were using improved drinking water sources.

The water resources of the Nile Basin provide a huge potential for consumptive and non-consumptive uses. The potentials for hydropower generation in the Upper Nile Basin remain largely underdeveloped. Egypt has largely developed its potentials for hydropower and there the proportion of electricity generated through hydropower is declining due to the sharp increase in electricity demands. Countries like Ethiopia and Burundi generate currently 95% of their electricity needs through hydro-power and there are still have huge potentials for hydropower in the Upper Nile Basin.

Table 3.4 Proportions of Hydropower produced by Various Riparian States

Country	Proportion from Hydropower	Remarks
Uganda		
Tanzania		
Sudan	30%	After completions Merowe plant 2010
Rwanda		
Kenya		
Ethiopia	96%	Three new plants (2000 MW) under construction
Egypt	15%	% Declined due to sharp increase of demand
DR Congo		
Burundi	95%	

There is an urgent need to create a more equitable development, for which economic growth and collaboration within the basin are preconditions. It will be difficult to build benefit sharing transboundary initiatives. The hugely diverse social and economic environment, inhabited by economies with few linkages between one another and with massive divergence in financial strength, economic structure and growth trajectories will make this not easy. The key issue arising from the diversity of contexts is to develop solutions for benefit sharing that begins with the actual needs of the people. One starting point may well be a clearer focus on addressing poverty, defined in human development terms.

3.4 Water related diseases

Existing data on the incidence of water-borne, water-related and water washed diseases indicate that these are mostly prevalent in areas where people use contaminated water as drinking was or have little water available for daily use. The information shows that such water related diseases count for over half of the diseases affecting the population. However their occurrence has greatly decreased with the provision of improved drinking water and public awareness campaigns (e.g. Egypt).

The swamps in the Upper Nile Basin and the irrigation systems in the plains are open waters that function as breeding grounds for mosquitoes. Therefore malaria is widely spread in the swamps and irrigation schemes, with the exception of Egypt where it is rare. Also Bilharzia flourishes in streams and swamps with low water velocities, where farmers are in constant contact with the water. Consequently, farmers in irrigation schemes have fallen prey to the disease.

Water borne diseases such as dysentery, cholera and typhoid fever have remained a leading cause of mortality and morbidity in the Upper Nile Basin Uganda particularly among vulnerable groups. Water borne diseases are acquired through consumption of water contaminated with faecal matter as a consequence of poor hygiene and sanitation. Many people in the rural areas and to a large extent, peri-urban slum areas, depend on on site sanitation, predominantly pit latrines, which has contributed to ground water contamination.

Incidences of river blindness have been reported in some parts of western Uganda.

3.5 Gender issues

Gender awareness raising activities in the water sector focus on the involvement of women in community based organizations that are established for environmental services and irrigation management. NGOs that are active in these fields pay special attention to that local female leaders participate in these voluntary organizations.

The water administrations in Egypt and Ethiopia have established a Gender Focal Point and a Women's Affairs Department that perform an advocacy role for women representation in newly established water boards and water users organizations. These units also prepare manuals and guidelines, and conduct trainings for the staff of the water administrations to raise their awareness on gender issues in water resources management.

4 Key Environmental Issues

Deforestation in the Blue Nile basin has been so severe that relatively few forests remain in western Ethiopia or northern Sudan. Forest area in Ethiopia as a whole decreased from 16% to 2% of the land area between the 1950s and 1980s. The use of former forest and grazing lands for crop cultivation without adequate soil protection has dramatically increased soil erosion, compounded by increasing numbers of livestock being forced onto shrinking pastures. About half of the Ethiopian highlands in the Blue Nile basin are presently significantly eroded, with some 20,000 square kilometers of agricultural lands having topsoil less than 10 centimeters deep and insufficient to sustain agriculture. By 2010, the extent of such land is expected to increase to around 100,000 square kilometers or almost 20% of the highlands.

In the Lake Victoria Basin deforestation has primarily been driven by population increase and the demand for wood for household and commercial fuel, for drying fish, curing tobacco, baking bricks; wood for use as building materials and other forest products for medicinal use. Forest destruction have accelerated due to recent refugee influxes. Sugar cane, tea and coffee estates have replaced large areas of forests while marginal lands are being overgrazed by livestock. These changes have led to soil erosion, increased flooding and surface runoff as well as large application of agricultural chemicals causing siltation and excessive nutrient loads in the lake.

Demographic pressures in the Kagera Basin have led to deforestation as wood is harvested for firewood and land cleared for agricultural production. Forest clearing for agriculture has now exceeded sustainable limits in parts of Burundi, DR Congo and Rwanda. Associated with population pressure and land clearing are problems of soil erosion as land parcels are subdivided and farmed more intensely. Soil erosion and depletion are now widespread throughout the basin.

In the Lower Nile Basin, Egypt is losing 13.000 hectares of agricultural land along its banks each year as a result of expanding settlements mainly in the outskirts of existing cities. Erosion of the Nile Delta has increased since 1970 when completion of the Aswan High Dam stopped the annual flood with its replenishing sediment. Severe coastal erosion has been observed in several sections of the Delta, while soil salinity and waterlogging of irrigated croplands are increasing, compounded by inappropriate farming practices. Overgrazing and vegetation removal have increased the risks of desertification at the fringes of the basin. Significant areas of irrigated land are affected by desertification to some degree, causing serious productivity losses. In both Sudan and Egypt, sand encroachment from desert onto nearby farmlands occurs, threatening agricultural development, settlements and traffic flows.

4.1 Wetlands, Lake Degradation and Biodiversity Loss

Wetlands in the Nile basin are threatened by drainage (for agriculture, industry and settlements), filling (for solid waste disposal, roads and settlements), dredging and stream channelization (for navigation and flood protection), hydrological alteration (for canals, roads and other structures), groundwater abstraction, siltation, and discharges of pesticides, herbicides, and sewage. All of these reduce the value and productivity of wetlands. In some cases waste loads have increased to such an extent that the wetlands' natural capacity as buffer and filter for sediments and certain pollutants is exceeded.

The Nile basin's most polluted wetlands are in the Nile Delta, where irrigation drainage water, untreated or partially-treated urban wastes and industrial effluents have destroyed several forms of aquatic life, reduced the productivity of fisheries and contaminated the fish catch. Elsewhere, Uganda's rich and extensive wetlands have been seriously degraded by conversion to agriculture, overexploitation for timber (for construction and fuel), papyrus (for construction, fuel and handicrafts), grasses and sedges (for thatch), and wild food plants and medicines. Shifts to use as pasture land followed by overgrazing have caused soil erosion on former reed swamps, while many former papyrus wetlands are no longer able to protect pastures, croplands and settlements from flooding. Other wetlands in Uganda have been lost or degraded by drainage and reclamation for dairy farming and rice growing, by burning, by clay extraction for brick making, by conversion to industrial sites and by pollution from sewage, industrial effluents and garbage dumping, especially in and around Kampala.

In neighbouring Kenya, the wetland area is reducing and eutrophication is increasing and furthermore “classic” wetland functions are under threat. For instance, the Yala swamp in the lake basin. Wetlands located upstream reduce the floods and filter the flow but are now under increasing threat.

Although irrigation schemes often replace wetlands, they can also result in new artificial wetlands. Certain irrigated rice paddy schemes have reproduced some of the same ecological characteristics as natural ecosystems, such as Doho and Kibimba in Uganda and Ahero in western Kenya. This has supported biodiversity conservation to the extent that wetland animals and plants can colonize these schemes without becoming a threat to the crops being grown there.

Lake Victoria and Kagera River Basins receive significant quantities of raw or partially treated sewage and industrial effluents from rapidly expanding lakeshore settlements. Overflowing pit-latrines and septic tanks as well as contaminated storm water also pollute the lake and its feeder rivers, increasing the incidence of waterborne diseases. Breweries and factories processing sugar, paper and textiles discharge their pollutants directly into the rivers and lake. While pollution management plans have been prepared and implemented by some of the leather tanning, fish processing and sugar factories, breweries and abattoirs along the lakeshore, these are exceptions. Heavily polluting, small-scale gold mining is also increasing in the basin and small quantities of other heavy metals such as chromium and lead have been detected in Lake Victoria.

The number of economically important fish species in the Lake has declined during recent decades from about twenty species to only two or three, mainly the introduced Nile perch and tilapia. The primary cause of the changes in water quality is not known, although it is probably related to nutrient enrichment. Eutrophication is now considered to be the greatest threat to the lake and the Kagera basin; it has been accompanied by the proliferation of aquatic weeds, including water hyacinth, elephant grass and algal blooms. The greatest contribution of water hyacinth plants to Lake Victoria originates from the Kagera River. Water hyacinth has spread rapidly over an area of several thousand hectares, choking important waterways and adversely affecting fishing, navigation, hydropower generation, water supply, tourism and rec-agricultural purposes; obstruction of waterways, dams, and hydropower generation facilities; and threats to many other lakeshore activities and biodiversity in the lake. Some improvements and a decrease in the extent of water hyacinth have been observed in recent years. This has been attributed to various factors, including successful biological weed control supported by the Lake Victoria Environmental Management Program (LVEMP).

Biodiversity losses are experienced in all the Nile's lakes, wetlands, savannas and dry and wet forests. While in Lake Victoria introduction of alien fish and plant species plays the major role, loss and fragmentation of habitat as a result of conversion, destruction or exploitation are the main threats in other areas.

4.2 Water Quality Degradation

Point source pollution from insufficiently treated domestic, urban and industrial wastes is mainly concentrated around settlements and factories and for the most part serious around urban centers such as Kampala, Khartoum, Cairo and other urban centers in Egypt. While non-point source pollution mostly caused by unsuitable use and/or excessive use agricultural chemicals (fertilizers, pesticides and herbicides) is a regional problems which has reduced water quality in many areas. Hotspots include large irrigation schemes in Sudan and Egypt and nutrient pollution from agricultural areas around Lake Victoria and its tributaries.

4.3 Sedimentation

Sedimentation problems are closely related to soil erosion problems. High sediment loads are found in many rivers, especially those draining the mountainous areas that are severely affected by soil erosion. Sediment loads are very high in the Blue Nile, the Atbara and the rivers of the Kagera basin, as well as many of the other rivers flowing into Lake Victoria. These sediment loads from the upper catchment can increase by up to 30 percent during droughts. Sedimentation in the White Nile catchment is also serious although the many lakes and wetlands in the basin do trap much of the sediment and the flatter terrain is somewhat less susceptible to soil erosion. High sediment loads have adverse effects on canals in the major irrigation schemes and can degrade small wetlands and reduce the capacity of shallow lakes. Siltation of major reservoirs imposes direct economic costs by reducing the efficiency of irrigation and power production, sometimes necessitating expensive desilting operations. Sediment and debris carried by the Blue Nile, the Atbara and their tributaries affect water quality in Sudan's reservoirs and irrigation canals, especially the Sennar, Roseires and Khasm El Girba reservoirs and the Gezira, Rahad and HaIfa irrigation schemes. The loss of reservoir capacity can be as high as 40 percent (30 percent in Sennar, 10 percent in Roseires and 40 percent in Khasm El Girba). Special procedures are required at Roseires to suspend energy production while flushing the bulk of the sediment that arrives at the beginning of the flood season through the reservoir and dam. Sediment deposition in some parts of the Nile between Atbara and Lake Nasser (Lake Nubia) has formed islands and sediment bars, leading to cross currents that have caused bank erosion and the loss of fertile soil and mature trees. Almost all of the sediment carried to the Nile's lower reaches becomes trapped in the Aswan High Dam, a reservoir which is estimated to have a large enough capacity to store sediment inputs for hundreds of years without impairing hydroelectric power generation.

4.4 Sea Water Intrusion

Sea water intrusion is only significant in the coastal area in Egypt and near aquifers in the northern part of the Nile Delta. The Delta covers an area of about 15,000 square kilometers and its aquifers contain about 130,000 million cubic meters of fresh water. Groundwater is pumped for irrigation purposes in large quantities. Over-extraction at a rate that exceeds the recharge rate leads to seawater intrusion in the coastal aquifers. As saltwater has a higher specific gravity than freshwater, it results in a freshwater layer of varying thickness above the brackish to saline water. Although some unconfined aquifers close to the coast receive considerable recharge from rain and surface water infiltration, excessive pumping still results in saltwater intrusion. The resulting high salinity of the coastal aquifers limits usability of the water.

4.5 Waterborne Diseases

The most serious waterborne diseases in the Nile basin are malaria, diarrhea and bilharzia (schistosomiasis), all of which are prevalent throughout the basin. Malaria is the single most important cause of death in most Nile countries. Basin-wide, diarrhea is the major cause of death among small children and is often related to contact with and consumption of drinking water polluted by discharge of partially treated or untreated sewage, compounded by insufficient hygiene education. Significant improvements have been achieved in Egypt in recent years through programs specifically addressing this problem, yet in other parts of the basin death of the young and very old due to intestinal diseases remains a large problem. Bilharzia, which occurs only in slow-moving water, has increased to become the most significant waterborne disease in Egypt since construction of the Aswan High Dam. Other water related diseases widespread in the basin include typhoid, hepatitis, bacterial dysentery, kidney disorders and a variety of intestinal parasites. Sedimentation, the spread of aquatic weeds and slow-moving waters in canals and rivers have all provided favorable conditions for waterborne diseases to proliferate.

4.6 Floods and Droughts

Flooding is a serious problem in the Nile basin due to the high variability of both climate and river flows, compounded by the dependence of large numbers of people on the floodplains for their livelihood. Floods have also had some very beneficial effects historically, by increasing land fertility, recharging shallow aquifers and reducing irrigation costs. Four types of floods can be distinguished. The first occurs in the Equatorial Lakes basin, where flashy rivers and localized heavy rainfall in the mountains lead to crop and property damage in the floodplains. The second type occurs around Lake Victoria itself, an area at risk from changes in the lake level; such an occurrence in 19611964 inundated farms, submerged infrastructure and damaged port facilities and lake transportation systems. Lake Victoria levels have not been stable and the risk of major flooding persists. Floods around Lake Kyoga in Uganda had similar impacts in 1997-1998. Both of these flood events had measurable negative impacts on economic growth, agricultural production and exports, and contributed to an increase in food prices and general inflation. The third flood type takes place in Sudan and Ethiopia, particularly in the Baro/ Akobo basin, where exceptional wet seasons cause large-scale floods that damage agricultural crops and irrigation facilities and displace large numbers of people. Floods in 1988 and 1998 were some of the most damaging ever recorded. Extensive damage was caused to crops, livestock, water pumps, wells, canals, roads, houses, schools and health centers. Possible climate change may make such severe flood events more frequent in the future. A final type of flood event occurs in arid areas, where flash floods derived from short but intense storms sometimes result in considerable damage and loss of life. At present there is no integrated flood warning system for the basin. For the Eastern Nile region, the Flood Preparedness and Early Warning (FPEW) project, to be implemented by ENTRO as from 2007, will put in place regional coordination mechanisms, strengthen flood preparedness and flood mitigation planning, and will design a regional flood forecast, warning, and communication system.

Drought is a major problem in the Ethiopian highlands and throughout the semi-arid parts of the Nile basin. Sudan has been very seriously affected, with many human and livestock fatalities in a succession of dry years from 1978 to 1987, which also caused three million people to resettle near the Nile and in urban areas. Drought problems in Sudan appear to be increasing due to reduced rainfall and desertification. Ethiopia has experienced at least fourteen major droughts since 1965, with millions of people affected and enormous losses of life in the worst years. Localized droughts occur periodically throughout the basin and have recently been associated with severe hydroelectric power deficiencies in Kenya. While Egypt used to suffer from devastating droughts, the Aswan High Dam has been able to store sufficient water to maintain supplies in very dry years when the only losses suffered have been from reduction in hydropower production and the associated costs of increased thermal power generation. Delayed wet seasons in the more humid, southern parts of the basin have severely damaged crops and livestock. Substantial monitoring efforts have been made in recent decades to provide early warning of impending droughts. Enhanced drought mitigation mechanisms are still needed, however.

4.7 Transboundary Environmental Issues

The main transboundary environmental issues in the Nile basin identified in the "Transboundary Environmental Analysis" Report (UNDP/World Bank/GEF 2001) are as follows:

- *Physical or chemical impact that cross national boundaries downstream*- deforestation and soil erosion can increase vulnerability to drought and lead to increased sedimentation and greater floods downstream, while sediments also accumulate in wetlands and reservoirs. Urbanization, industrialization and increased use and improper application of pesticides and fertilizers lead to increased runoff and pollution that harm downstream water users.
- Loss of 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. Significant transboundary benefits derive from various ecosystems' roles in maintaining water quality, trapping sediment, retaining nutrients, buffering floods, stabilizing micro-climates and providing storm protection.
- *Need for trans boundary cooperation to protect key habitats.* Many key plant and animal species have habitats in adjoining countries, often requiring cross-border protected areas and other conservation measures for effective management. For example, the Nile is a principal flyway for birds migrating between central Africa and Mediterranean Europe, and Nile wetlands in a variety of countries provide indispensable habitats for these birds.
- *Lack of early warning systems.* Floods and droughts due to climatic conditions compounded by inadequate land management regularly affect many parts of the basin, causing considerable human suffering and ecological damage.
- *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.
- *Waterborne diseases* such as malaria, diarrhea and bilharzia (schistosomiasis) 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.

It is noted however that the Lake Victoria Environmental Management has been addressing several of these issues and a body of technical information is reportedly available.

5 Availability of Data

Data availability is a critical issue for the design of the DSS. Any model needs reliable data for calibration and validation, and the wide range of (potential) effects of water decisions is reflected by a considerable variety of data requirements.

Not surprisingly, data availability in the Nile basin varies in a wide range, according to the state of socio-economic development, the predominant issues, climate and stability of each country; sometimes it depends on a single initiative, usually supported by international organisations, whether data are being collected or not.

5.1 Meteorological data

Meteorological data collection has generally encountered a serious reduction in the last decades. In particular the dense raingauge networks have been reduced, sometimes drastically. (Rainfall for example, reduced from about 500 on 1940 to about 400 on 1960 to less than 300 now in the White Nile basin. The operational network is still relatively dense in Kenya, Uganda and Ethiopia. The situation in the Nile basin area of DR Congo and in Southern Sudan is not known but it can be assumed that data collection activities are very limited or non existent.

A core network of meteorological stations, either classical or automated stations, is available in all countries except DR Congo, but the detailed assessment of areal precipitation is difficult, in particular in mountainous and hilly areas where orographic effects occur. It is recommended to increase the number of meteorological stations and to take advantage of remote sensing techniques to interpolate between ground stations.

Telemetry is hardly used in any of the Nile basin countries. It is recommended to promote, in the context of NBI-DSS development, the definition of a core network of stations to be equipped with automated equipment and linked to a telemetry system (ideally networked at the Nile basin level).

Table 5.1 Meteorological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
Kagera	Burundi	90 rainfall 12 meteo	16 rainfall 11 meteo	Since 1922, typical length about 30 years	IGEBU, Gitega	Hydro-meteorological database (Access) established by FAO-Nile (2002), historical data are partially entered	Deterioration of the network in the 1990s
	Rwanda	155 rainfall 11 meteo	6 rainfall 5 meteo	Since 1906, typical length 25 years	Rwanda Meteorolog. Service, Min. of Infra-tructure	CLICOM database, most data until 1993 but new data are being entered	Most data available until 1993, few stations resumed after 1994
			~ 3 meteo		ISAR		
			~ 7 meteo	recent stations	Ministry of Health		Anti-malaria programme

Table 5.1 Meteorological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
	Tanzania	8 rainfall (TMA: 2) 1 meteo (MoW)		Since 1942 (TMA)	Tanzania Meteorological Agency (TMA) Ministry of Water (MoW)	Many records end in the 1990s as databases have not been updated. Records of meteorological stations are up to date.	TMA has fewer but longer data series. There are other stations with short or unreliable records.
Lake Victoria	Tanzania	150 rainfall (TMA: 22) 7 meteo: (3 TMA, 4 MoW)		Since 1921 (TMA), long series available			
	Kenya	700 rainfall + 20 new recording raingauges at least 20 meteo	91 rainfall + 20 recording raingauges from LVEMP 20 meteo	Since 1900 (KMD), long series available	WRMA Lake Victoria North and LV South Regions Kenya Meteorological Department LVEMP	Database at KMD (CLIMSOFT) Regional databases for LV North and LV South Regions (WRMA)	Many of the 700 historical raingauges have been closed but data are available at KMD. Source of climate date and resources based in Nairobi: ICPAC (IGAD Climate Prediction and Applications Centre)
	Uganda	Up to 1000 stations *(all of Uganda)*	300 rainfall 23 meteo *(all of Uganda)*	Meteorol. Data since over 100 years	Uganda Department of Meteorology (6 meteo stations operated by DWRM)	UDM: CLICOM database, will be changed to CLIMSOFT	Station numbers by sub-basin currently not available
Victoria Nile	Uganda						
Semliki – Lake Albert	DRC	20 stations (type not specified) existed in the 1960s	Unknown, probably none	Since 1911, typical length 25 years	Institutions collecting climatological data included: METTELSAT, INERA, ICCN and SNEL	METTELSAT has an Access database; otherwise data management is highly deficient, some of the data may be lost or very difficult to retrieve.	Most stations stopped functioning in the 1960s already. The Nile basin is on of the regions that were most affected by armed conflict, the equipment was destroyed and there is no more data collection in most of the sites.
	Uganda	Up to 1000 stations *(all of Uganda)*	300 rainfall 23 meteo *(all of Uganda*	Meteorol. Data since over 100 years	Uganda Department of Meteorology (6 meteo stations operated by DWRM)	UDM: CLICOM database, will be changed to CLIMSOFT	Station numbers by sub-basin currently not available
Albert Nile – Bahr el Jabal	Uganda						

Table 5.1 Meteorological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
	Sudan						Information for Southern Sudan to be compiled
Bahr el Ghazal	Sudan						
Sudd	Sudan						
Baro - Akobo - Sobat	Ethiopia	42 rainfall 6 meteo	Network operational	Since 1952, Typical record legth about 15 years	National Meteorological Agency (NMA)	National meteorological database (clidata) ; improvement of database and digiti-zation of all historical data underway	Dense network but less coverage of lowland areas
	Sudan	Historical peak: 589 stations (Sudan total)	Total Sudan: 36 meteo 72 rainfall		Sudan Meteorological Authority	Sudan Agro-Meteorol. Information System (SAMIS)	Information for Southern Sudan to be compiled. Distribution of meteorlogical station by sub-basin currently not available
Lower White Nile	Sudan						
Blue Nile	Ethiopia	173 rainfall ~10 meteo	Network operational	Typical record legth about 15 years	National Meteorological Agency (NMA)	National meteorological database (clidata) ; improvement of database and digiti-zation of all historical data underway	Dense network but less coverage of lowland areas and high elevation areas
	Sudan	Historical peak: 589 stations (Sudan total)	Total Sudan: 36 meteo 72 rainfall		Sudan Meteorological Authority	Sudan Agro-Meteorol. Information System (SAMIS)	Distribution of meteorlogical station by sub-basin currently not available
Main Nile 4	Sudan						
Tekezze - Atbara	Ethiopia	80 rainfall ~8 meteo	Network operational	Since 1951, Typical record legth about 15 years	National Meteorological Agency (NMA)	National meteorological database (clidata) ; improvement of database and digiti-zation of all historical data underway	Dense network but less coverage of lowland areas and high elevation areas Many data gaps, partially filled for Integrated Master Plan Study
	Eritrea	1 station (Omhajer)	none	Since 1919	Ministry of Agriculture		Station not operating due to secutiry reasons
	Sudan	Historical peak: 589 stations (Sudan total)	Total Sudan: 36 meteo 72 rainfall		Sudan Meteorological Authority	Sudan Agro-Meteorol. Information System (SAMIS)	Distribution of meteorlogical station by sub-basin currently not available
Main Nile 3	Sudan						
	Egypt		?		Egyptian Meteorological	Details on existing an d planned databases to	Distribution by sub-basins
Main Nile 2	Egypt		112	EMA			

Table 5.1 Meteorological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
Main Nile 1	Egypt		meteo	established in 1900	Authority (EMA)	be completed	currently not available. There seem to be very few stations around Lake Nasser (Main Nile 3 basin).

In the above table the number of rainfall stations includes meteorological stations. Meteorological stations measure, apart from rainfall, at least the following parameters: Air temperature, air humidity and wind speed, solar radiation, sunshine duration and atmospheric pressure; in many cases pan evaporation and soil temperature are also measured.

5.2 Hydrological data – surface water resources

Hydrological data collection (streamflow monitoring) activities generally show a significant deterioration: Both the density of the networks and the reliability of the collected data have been in decline for many years, the latter typically because hydrological services do not have the means to visit the stations regularly and update the rating curves. In two countries, Rwanda and DR Congo, hydrological data collection is interrupted since many years and has not yet resumed; in Burundi, many stations have been abandoned and rating curves have not been updated since the early 1990s. In Kenya data collection was intensive until recently but has suffered from institutional changes. In Uganda the basic network is operational. In Sudan many stations have been abandoned or need rehabilitation, and due to a lack of discharge measurements few stations produce discharge data; information for Southern Sudan is not available but it is clear that most of the historical stations have ceased to operate. The operational network is relatively dense in Ethiopia where data collection and analysis activities have been strengthened by the River Basin Integrated Master Plan Studies. In Egypt, hydrological data collection means essentially monitoring of water releases at the different water control structures; this is done in a comprehensive manner and making use of a telemetry system.

Generally, the degree of automation of the hydrometric networks is still very low, and telemetry is not used in most countries (except Egypt). Most recorders are out of order, and real time data are not available.

It is recommended to consider, in the context of DSS development and implementation, to promote the establishment of a core network of well maintained stations that are linked to a regional teletransmission network (see conclusions and recommendations, section 5.8).

Table 5.2 Hydrological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
Kagera	Burundi	21 + 3 lake stations	12 (none recording)	Since 1973, typical length about 20 years	IGEBU, Gitega	Hydro-meteorological database (Access) established by FAO-Nile (2002)	Data are unreliable as rating curves are not (no gaugings; last rating curve dates from 1990).

Table 5.2 Hydrological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
	Rwanda	32 (about 20 with flow data) + up to 13 lake stations	3 stations recently reinstalled (recording, but no new rating curve yet)	Since 1956 typical length about 20 years	Ministry of Lands, Environment, Forests, Water and Mines (MINITERE)	Access database holds historical hydrological data (as well as other water resources data)	Current data are unreliable as no gaugings are made since 1990. Rehabilitation of 14 stations planned. In 2008 two stations will be installed by NELSAP-Kagera IWRM project
	Tanzania	10 (at least 5 with flows)	Operational status: ?	Since 1947 (Kyaka Ferry)	Lake Victoria Basin Water Office	Most records end in the 1990s as databases have not been updated. No recent time series available.	Data are also available at the Ministry of Water. There were a few other stations but no records are available.
Lake Victoria	Tanzania	18 (2 recording)	Operational status: ? (recorders not functional)	Since 1966			
	Kenya	228 + 3 lake stations	84 (1 recording)	Since 1922 Average length of record: 25 years	Data collection taken over from MWI by WRMA LV North and LV South catchment regions	WRMA LV South and LV North regions each maintain a regional database. Real time data transmission (automated network) planned. Historical data are available at the Ministry of Water and Irrigation.	Data collection taken over from MWI by WRMA in 2005; many stations were closed in this context. Continuous series 1950-2004 produced by LVEMP project.
	Uganda		16 + 3 lake stations		Directorate of Water Resources Management, Ministry of Water and Environment	Data stored in a database at DWRM	Most gauging stations equipped with water level recorders
Victoria Nile	Uganda		26 + 2 lake station				
Semliki – Lake Albert	DRC	2 stations on Semliki (colonial times)	none	Unknown, no recent data available	There is no hydrographic service. Some parastatals (SNEL, RVF) collect data for their purposes (hydropower, navigation)	No recent data available	It is envisaged that in a new decentralised setup river basin agencies will be responsible for data collection.
	Uganda		8 + 3 lake stations		Directorate of Water Resources Management, MWE	Data stored in a database at DWRM	Most gauging stations equipped with water level recorders
Albert Nile	Uganda		7				

Table 5.2 Hydrological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
– Bahr el Jabal	Sudan	~ 30	Information not available				Information for Southern Sudan to be compiled
Bahr el Ghazal	Sudan	41	Information not available				
Sudd	Sudan	~ 50	Information not available				
Baro - Akobo - Sobat	Ethiopia	24	24		Ministry of Water Resources, Hydrology Dept.	Hydrological database (HYDATA)	Gaps filled and data analysed by Baro-Akobo River Basin Integrated Master Plan Study
	Sudan	~ 45	Information not available				Information for Southern Sudan to be compiled
Lower White Nile	Sudan	16	At least 4 stations with discharge data				
Blue Nile	Ethiopia	124	106		Ministry of Water Resources, Hydrology Dept.	Hydrological database (HYDATA)	Gaps filled and data analysed by Abbay River Basin Integrated Master Plan Study
	Sudan	18 plus 9 stations on dams and irrigaton structures	No. of operational stations not exactly known; some need rehabilitation	Date available since 1906 (El Roseires)	Nile Waters Department (5 stations) Egyptian Irrigation Department (13 stations) Dams Administtration (Sennar and El Roseires Dams) Irrigation Services Dept.	Data partly available at NWD	No functional recorders, no teletransmission Inflow from Ethiopia monitored by Ed Deim station
Main Nile 4	Sudan	5	At least 2 stations with discharge data	Date available since 1906 (El Hudeiba)	Egyptian Irrigation Department Nile Waters Department	Data partly available at NWD	No functional recorders, no teletransmission
Tekezze - Atbara	Ethiopia	31	26		Ministry of Water Resources, Hydrology Dept.	Hydrological database (HYDATA)	Gaps filled and data analysed by Tekeze Basin Integrated Master Plan Study
	Eritrea	1 (Setit)	none	Station installed in 1995	Water Resources Department	Few years of data, unreliable rating curve	Station closed due to security concerns

Table 5.2 Hydrological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	No. of stations (Nile basin only)		Longest time series	Institution collecting data	Database / data availability	Commentary
		Historical max. no.	Current no.				
	Sudan	15	Only 4 stations produce discharge data, many need rehabilitation	Date since 1903, two stations with > 40 years of record	Nile Waters Department Egyptian Irrigation Department (downstream of El Girba dam) Dams Administtration (El Girba dam)	Data available at NWD (data stored as hardcopy and as Excel spreadsheets)	No functional recorders, no teletransmission Hamdayeet gauge site at the border not operational due to security problems
Main Nile 3	Sudan	15 (most to record water levels only)	At least 2 stations with discharge data Some stations out of order, serveral need rehabilitation	Date available since 1906 (Dongola)	Egyptian Irrigation Department (most stations) Nile Waters Department	Data partly available at NWD	No functional recorders, no teletransmission
	Egypt				Aswan High Dam (AHD) Authority	All data related to AHD require approval of AHD Authority	
Main Nile 2	Egypt	n/a	Dense network 10 main points (on barrages and main canals)		MWRI Irrigation Sector	Data available upon receiving official letter	Dense measurement network on distribution system, including telemetry. In most cases flow is calculated from water regulation structures.
Main Nile 1	Egypt	n/a	13 main points downstream of Delta barrage				

5.3 Hydrogeological data - groundwater resources

Groundwater levels are rarely monitored on a regular basis but rather sporadically in the context of studies or projects. Regular groundwater monitoring programmes are operational in Kenya, Uganda (network density insufficient) and Egypt. In Ethiopia a Groundwater Resources Assessment Programme is in the start-up phase.

Hydrogeological data are often scattered, and often there is no dedicated hydrogeological service. Where data are available, eg from borehole drilling campaigns, these data are often not analysed and interpreted in a systematic way. In most countries hydrogeological studies and data are handled by different institutions (typically the authority responsible for geology and mines) and there is insufficient information exchange between these institutions and the ones responsible for water resources management. An exception is Kenya where Water Resources Management Authorities have been established at the basin level.

Table 5.3 Hydrogeological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
Kagera	Burundi	Borehole database (Excel) available at Geological Service; springs (inventory not complete) and boreholes are also stored in the PDNE database at DGEE/DRH and in the rural water supply database at DGHER (both Access); a new inventory is currently underway. Additional information is available from mining research studies. Geological maps: 1:250,000 (1990) and 1:100,000 (1976-1988)	Ministry of Energy and Mines, Bujumbura	Borehole database of Geological Service seems to be partly lost due to IT problems; PDNE database not updated since 1996; Relevant studies and reports need to be reviewed to compile and synthesise all available information. Comprehensive groundwater assessment needed.
	Rwanda	Groundwater related data (springs, borehole data) are included in the water resources database at MINITERE. Borehole data are available from PDCIU project (Mutara, FAO support) and from a JICA project (South-East Rwanda)	Ministry of Lands, Environment, Forests, Water and Mines (MINITERE)	There is no hydrogeological service. A groundwater potential map has been produced by the National Water Resources Management Project. Systematic retrieval of scattered groundwater related information necessary to establish a comprehensive water resources database
	Tanzania	Groundwater related data are scattered. Details on data availability are not known at this stage		
Lake Victoria	Tanzania			
	Kenya	Groundwater data is collected at 25 sites (groundwater level and quality); level measurements once per month. Data storage at LV North / LV South region.	WRMA LV North and LV South catchment regions	
	Uganda	7 groundwater monitoring stations in this sub-basin	Directorate of Water Resources Management	Some of the stations are equipped with a water level recorder. Groundwater monitoring started in 1998.
Victoria Nile	Uganda	7 groundwater monitoring stations in this sub-basin		
Semliki – Lake Albert	DRC	A database (Access) containing metadata on geology and mining is under preparation (launched in 2006 with support from the Royal Museum of Central Africa (Tervuren, Belgium)	CRGM - Centre of Geological and Mining Research	Data availability for the Nile basin area unknown
	Uganda	2 groundwater monitoring stations in this sub-basin	Directorate of Water Resources Management	Groundwater monitoring started in 1998.
Albert Nile – Bahr el Jabal	Uganda	no groundwater monitoring stations in this sub-basin		
	Sudan			Information for Southern Sudan to be compiled, including documentation produced or compiled by UN agencies and relief programmes
Bahr el Ghazal	Sudan			
Sudd	Sudan			
Baro - Akobo - Sobat	Ethiopia	Hydrogeological mapping 1:250,000 underway (existing coverage: 1:2,000,000)	Geological Survey of Ethiopia	See also: Baro-Akobo River Basin Integrated Development Master Plan, 1997 In start-up phase: Ethiopian Groundwater Resources Assessment Programme

Table 5.3 Hydrogeological Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
	Sudan	Numerous studies and publications, no regular monitoring programme	Groundwater and Wadis Department, MoIWR-WRD	Groundwater corporations at state level
Lower White Nile	Sudan			
Blue Nile	Ethiopia	Hydrogeological mapping 1:250,000 underway (existing coverage: 1:2,000,000)	Geological Survey of Ethiopia	See also: Abbay River Basin Integrated Development Master Plan, 1999 In start-up phase: Ethiopian Groundwater Resources Assessment Programme
	Sudan	Numerous studies and publications, no regular monitoring programme	Groundwater and Wadis Department, MoIWR-WRD	Groundwater corporations at state level
Main Nile 4	Sudan			
Tekezze - Atbara	Ethiopia	Hydrogeological mapping 1:250,000 underway (existing coverage: 1:1,000,000) Water point inventory available (720 points in Tekeze basin)	Geological Survey of Ethiopia	See also: Tekeze River Basin Integrated Development Master Plan, 1998; Mereb River Basin Integrated Development Master Plan, 1997 In start-up phase: Ethiopian Groundwater Resources Assessment Programme
	Eritrea	Currently no regular monitoring activities		Border area
	Sudan	Numerous studies and publications, no regular monitoring programme	Groundwater and Wadis Department, MoIWR-WRD	Groundwater corporations at state level
Main Nile 3	Sudan			
	Egypt	Number of monitoring stations not available	Research Institute for Groundwater, NWRC	Groundwater in the Nile valley and Delta region cannot be considered an independent resource as it gets recharged only from seepage losses (River Nile, canal and drainage network) and from deep percolation from irrigated land.
Main Nile 2	Egypt			
Main Nile 1	Egypt			

5.4 Water quality and sediment transport data

Water quality and sediment transport are monitored sporadically only in most Nile basin countries, except for sediment monitoring in the Eastern Nile region where this is a priority issue. Remarkable exceptions in the Equatorial Lakes region are Kenya and Uganda where an IWRM approach has been adopted with support by major programmes; in both countries there are dense networks to monitor both surface water and groundwater quality. Data collection in Tanzania was intensive during the Lake Victoria Environmental Project (LVEMP, 2000-2005).

There is a considerable amount of sediment transport data for the Ethiopian parts of the Blue Nile and the Tekeze-Atbara sub-basins. In Sudan there are a few sediment monitoring stations on the Blue Nile and on the Main Nile. Sediment deposition in Lake Nasser-Nubia is monitored through annual survey missions.

Table 5.4 Water Quality and Sediment Transport Data Availability by Sub-basins and Countries

<table>
<tr><th>SUB-BASIN</th><th>COUNTRY</th><th>Database / data availability</th><th>Institution collecting data</th><th>Commentary</th></tr>
<tr><td rowspan="3">Kagera</td><td>Burundi</td><td>There have never been regular analyses of surface water quality. The few data available are scattered. The only comprehensive study of surface water quality was done in 1988-89 (Sekamana, 1989; 30 sampling points in the Nile basin). Groundwater quality analyses have been made by different institutions. Water quality of the sources used for urban water supply is monitored by the water supply corporation REGIDESO.</td><td>No central database.</td><td>There is urgent need to compile, analyse and synthesise the available water quality information, both for surface waters and for groundwater.
Some water quality data may be found at the Ministry of Health (Dept. of Health Promotion, Hygiene and Sanitation)</td></tr>
<tr><td>Rwanda</td><td>There is no regular water resources quality monitoring programme. However, analyses are made in the context of water supply projects and there is a number of studies.</td><td>Ministry of Lands, Environment, Forests, Water and Mines (MINITERE)</td><td>The available water quality information, both for surface waters and for groundwater, should be compiled to complete the existing water resources database at MINITERE.</td></tr>
<tr><td>Tanzania</td><td rowspan="2">From year 2000 to 2005 the Lake Victoria Environmental Management Project (LVEMP) collected Total Suspended Solids (TSS) data and monitored lake water quality (29 stations), urban and industrial effluents as well as nutrient transport into the lake. Data are in Excel spreadsheets.
Data on groundwater quality are scattered.</td><td rowspan="2">Ministry of Water</td><td rowspan="2"></td></tr>
<tr><td rowspan="3">Lake Victoria</td><td>Tanzania</td></tr>
<tr><td>Kenya</td><td>Surface water quality (COD, colour, conductivity) is measured at 38 gauging stations, 4 samples per year.
Groundwater quality (pH, temperature, salinity) is monitored at 25 sites on a quarterly basis.</td><td>WRMA LV North and LV South catchment regions</td><td>Additional water quality data were collected by LVEMP (2000-2005) as well as earlier by the FAO programmes.</td></tr>
<tr><td>Uganda</td><td rowspan="2">Total Uganda:
36 stations for monitoring trends in river and lake water quality;
18 stations for monitoring trends in ground water quality;
34 stations for monitoring impact of on receiving effluent discharges;
12 stations for monitoring performance of water treatment;
5 stations for monitoring performance of sewage treatment.</td><td rowspan="2">Directorate of Water Resources Management</td><td rowspan="2"></td></tr>
<tr><td>Victoria Nile</td><td>Uganda</td></tr>
<tr><td rowspan="2">Semliki
– Lake Albert</td><td>DRC</td><td>There is no regular water resources quality monitoring. There may be some data on water quality of Lakes Edward and Albert in the context of fishery studies.</td><td>Ministry of Agriculture, Fishery and Animal Husbandry</td><td></td></tr>
<tr><td>Uganda</td><td>Total Uganda:</td><td>Directorate of</td><td></td></tr>
</table>

Table 5.4 Water Quality and Sediment Transport Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
Albert Nile – Bahr el Jabal	Uganda	As described above.	Water Resources Management	
	Sudan			Information for Southern Sudan to be compiled
Bahr el Ghazal	Sudan			
Sudd	Sudan			
Baro - Akobo - Sobat	Ethiopia	1 sediment sampling site (?) (4 years of data)	Ministry of Water Resources, Hydrology Dept.	
	Sudan	No regular monitoring of sediment transport or water quality		Some scattered information can be found in studies and publications
Lower White Nile	Sudan			
Blue Nile	Ethiopia	43 sediment sampling sites (up to 16 years of data; average: 6 years)	Ministry of Water Resources, Hydrology Dept.	
	Sudan	5 sediment monitoring stations (3 on Blue Nile, 1 on Rahad, 1 on Dinder)	Sediments: NWD Water quality: Khartoum Water Corporation Groundwater: GWD	Additional information can be found in a number of studies and publications
Main Nile 4	Sudan	No regular monitoring stations operating		
Tekezze – Atbara	Ethiopia	16 sediment sampling sites (average: 20 years of data)	Ministry of Water Resources, Hydrology Dept.	
	Eritrea	Currently no monitoring activities		Border area
	Sudan	There were temporary sampling campaigns, no regular monitoring programme	Surface water: NWD; Groundwater: GWD	Additional information can be found in a number of studies and publications
Main Nile 3	Sudan	1 station with sediment monitoring Historical sediment transport data available for 1929-1959		
	Egypt	<u>Sediments</u> in Lake Nasser: Annual survey mission. Yearly deposited sediment data available since 1964 <u>Water quality</u>: MWRI: 320 monitoring locations for surface water (along the Nile, canals and drains, Lake Nasser) and 250	Measurement of sediment in Lake Nasser: AHD and Nile Research Institute	MWRI: National Program for Water Quality Monitoring (accomplished in 2007). Substantial lab work carried out by Central Laboratory of Environmental Quality Monitoring, NWRC. Distribution of monitoring locations by sub-basins not known. Very limited data is available on pesticides, heavy metals and hydrocarbons. Little
Main Nile 2	Egypt		Water quality:	

Table 5.4 Water Quality and Sediment Transport Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability		Institution collecting data	Commentary
Main Nile 1	Egypt		for groundwater. MoHP: Quality of Nile water, industrial discharge, effluents from 86 wastewater treatment plants EEAA: Annual monitoring program for Nile water quality	Ministry of Water Res. and Irrigation (MWRI) Ministry of Health and Population (MoHP) Egyptian Environmental Affairs Agency (EEAA)	attention is also paid to pathogenic organisms and parasites. Comparability between data produced by the various agencies and sampling programmes is problematic. Continuity over time is also an issue.

5.5 Demographic and socio-economic data

Demographic and socio-economic data are relatively easy to obtain, mainly because there is always a national agency (Bureau of Statistics) in charge of collecting these data, and there are international quality standards for demographic, socio-economic and public health surveys.

However, the situation is more complicated for countries affected by conflict or in a post-conflict situation. Data availability is most problematic for DR Congo where the last census (of 1994) does not represent the current situation in the Nile basin area which has been strongly affected by migration and refugee/IDP movements, with a strong impact on the socio-economic and health situation. In Burundi the post-conflict situation will be established by a census planned for 2008. A new census for Sudan, which will include Southern Sudan, is under preparation.

Table 5.5 Demographic and Socio-economic Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
Kagera	Burundi	Major surveys are usually undertaken every 5 years, depending on funding: Household living conditions (last in 2007); Questionnaire on development indicators (QUID, last in 2002); Demographic and Health Survey. Data are held in various databases (Excel, SPSS, Acces), updating is not always regular. A new unified database will be created in conjunction with the planned new census in 2008. The last census was conducted in 1990.	ISTEEBU, Bujumbura	The planned national census in 2008 (the last was in 1990) will constitute an important base to establish the post-conflict situation. Data are in principle public but authorisation by the Director is required. DevInfo database has been set up with support from UNICEF. A database on IDPs has been established by PCAC (OCHA).
	Rwanda	Data availability according to rhythm of surveys. Major surveys are usually undertaken every 5 years: Demographic and Health Survey (DHS; survey of household living conditions; agricultural survey; food security / vulnerability survey. Last census: 2002 (next: 2012).	National Institute of Statistics	Comparison of data is complicated due to the reform of territorial administration (number of provinces and districts drastically reduced since 01.01 2006). Data are freely available (internet access planned).

Table 5.5 Demographic and Socio-economic Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
	Tanzania	2002 population and housing census 2000/1 Tanzanian Household Budget Survey 2002/03 National Sample Census of Agriculture Data are stored in electronic form.	National Bureau of Statistics (NBS)	Website: www.nbs.go.tz
Lake Victoria	Tanzania			
	Kenya	1999 population census 2005/6 Kenya integrated household budget survey (KIHBS) 2003/4 Kenya Demographic and Health Survey Data are stored in electronic form.	Kenya National Bureau of Statistics (Central Bureau of Statistics, CBS)	Website: www.cbs.go.ke
	Uganda	2002 population census 2005/6 Uganda National Household Survey 2004 National Service Delivery Survey	Uganda Bureau of Statistics (UBOS)	
Victoria Nile	Uganda			
Semliki – Lake Albert	DRC	Last census of 1994 (next one planned for 2010). Major surveys funded by international donors include Demographic and Health Survey (EDS, 2006-2007), the 1-2-3 survey (1-Employment, 2-Household, 3-Consumption) and the MICS survey.	INS (National Statistical Institute), Kinshasa	Data are currently stored in different formats. Two databases are under preparation: DevInfo, and a more comprehensive database for all statistical data.
	Uganda	2002 population census 2005/6 Uganda National Household Survey 2004 National Service Delivery Survey	Uganda Bureau of Statistics (UBOS)	
Albert Nile – Bahr el Jabal	Uganda			
	Sudan	Census under preparation 2006 Sudan Household Health Survey (SHHS)	Southern Sudan Commission for Census, Statistics and Evaluation (SSCCSE)	
Bahr el Ghazal	Sudan			
Sudd	Sudan			
Baro - Akobo - Sobat	Ethiopia	EthioInfo database Census and surveys as listed below (Blue Nile)	Central Statistical Agency	see CSA website www.csa.gov.et Economic information available from Ministry of Finance and Economic Development
	Sudan	Last census 1993; new census under preparation 2006 Sudan Household Health Survey (SHHS)	SSCCSE Central Bureau of Statistics	Census had been postponed but
Lower White Nile	Sudan			

Table 5.5 Demographic and Socio-economic Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Database / data availability	Institution collecting data	Commentary
Blue Nile	Ethiopia	EthioInfo database Poulation and Housing Census 2007 Demogr. and Health Survey 2005 Eth. Welfare Monitoring Survey 2004 Agric. Sample Enumeration 2001/2	Central Statistical Agency	List of available surveys is not exhaustive, see CSA website www.csa.gov.et Economic information available from Ministry of Finance and Economic Development
	Sudan	Last census 1993; new census under preparation 2006 Sudan Household Health Survey (SHHS)	Central Bureau of Statistics Bank of Sudan	
Main Nile 4	Sudan			
Tekezze - Atbara	Ethiopia	EthioInfo database Census and surveys as listed above (Blue Nile)	Central Statistical Agency	see CSA website www.csa.gov.et Economic information available from Ministry of Finance and Economic Development
	Eritrea			Information for Eritrea not available
	Sudan	Last census 1993; new census under preparation 2006 Sudan Household Health Survey (SHHS)	Central Bureau of Statistics Bank of Sudan	
Main Nile 3	Sudan			
	Egypt	13th census conducted by CAPMAS in 2006 Demographic and Health Survey, 2005 Egypt Integrated Household Survey, 1997-1999	Central Agency for Public Mobilization and Statistics (CAPMAS)	
Main Nile 2	Egypt			
Main Nile 1	Egypt			

5.6 Spatial / GIS data

Basic GIS layers are available in all countries as GIS activities have been promoted by various agencies and have received considerable international support since the 1990s. However, in most countries there was insufficient coordination of these activities, a fact that resulted in a variety of data formats, quality standards, reference grids and institutions involved in GIS mapping activities, and sometimes in redundant work.

The table below intends to provide a first overview based on existing reports and fieldnotes, but a full inventory of GIS layers and other spatial data/maps available in the Nile basin countres is yet to be established.

Table 5.6 Spatial Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Content of GIS	Institution where data are available	Software used, Commentary
Kagera	Burundi	Stream network Hydro-meteorological network Land cover 1:200,000 (AfriCover, 2002) Topographical maps 1:50,000 (on paper and scanned)	IGEBU	ArcView
		Administrative boundaries, 2005 Stream network, 1:50,000	BINUB/ UNDP/ UNICEF/OCHA	ArcGIS
		Administrative boundaries, natural regions, erosion, soils, rainfall; status 1996	Centre for Environmental Information (CIE), Ministry of Lands, Environment and Tourism (MINATET)	ArcView
		Set of GIS maps related to water management, status 1996	Ministry of Energy and Mines, DGEE/DHR	ArcView
		Pedological map, wetlands (paper maps only)	MINATET / MINAGRI	
	Rwanda	Soil map (1:50,000, 1994) Digital terrain model and hydrographical map (digitised from topographical maps 1:50,000) Geological map (1:250,000) Administrative boundaries	Pedology/GIS service of Ministry of Agriculture	ArcView/ArcGIS
			National University of Rwanda (UNR), Butare	
			Cartographical service of Ministry of Infrastructure	
		Wetlands mapping underway	Rwanda Environment Management Authority (REMA)	
	Tanzania	Lake Victoria basin boundaries, sub-basins	Ministry of Water University of Dar es Salaam	Best map produced by Lake Victoria Environmental Management Project (LVEMP)
		River network	Ministry of Water	
Lake Victoria	Tanzania	Maps of socioeconomic parameters by administrative units	National Bureau of Statistics	
		Detailed topographical maps, 1:50,000 / 1:25,000, digital	Ministry of Lands Survey Department	
	Kenya	Administrative boundaries Rivers and river basins Elevation contours, DEM	International Livestock Research Institute (ILRI), Nairobi	ArcView shape ASCII
		Wetlands, agro-ecological zones, forest cover, protected areas	ILRI	ArcView shape
		Maps of demographic and socioeconomic parameters by administrative units	Central Bureau of Statistics	ArcView shape

Table 5.6 Spatial Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Content of GIS	Institution where data are available	Software used, Commentary
		Maps of meteorological parameters, zones and networks	ILRI Kenya Meteorological Department	ArcView shape/grid
		Malaria zones (1999)	Welcome trust	ArcView shape
		Map of LBDA region; soil maps, agro-ecological zones, vegetation type	Lake Basin Development Authority (LBDA)	
	Uganda	Base maps (2004/5), administrative boundaries (2006), *(to be continued – see below)*		
Victoria Nile	Uganda			
		Rural water supply atlas, 2001	Directorate of Water Development (DWD)	ArcView shapes
		Rivers, catchment area boundaries Surface water, groundwater and water quality monitoring network Detailed groundwater mapping programme underway since 2001	Directorate of Water Resources Management	
		Wetlands, land cover, rivers (1996)	DWRM	Data originally from the Biomass study
Semliki – Lake Albert	DRC	Basic GIS shape files (reference scale 1:50,000) are available for the entire country: Administrative boundaries, streams and lakes, etc.; elevations are available from SRTM	OSFAC – Satellite Observatory of Central African Forests, Kinshasa	
	Uganda	Uganda *(contd.)* Soil types		International Soil Reference and Information Centre
Albert Nile – Bahr el Jabal	Uganda			
		Geology	Ministry of Energy and Mineral Development	
		Agricultural land, forest cover, etc. (2003)		AfriCover project
	Sudan	Southern Sudan Rivers (2004, 1:250,000)	FAO	Information for Southern Sudan to be compiled
Bahr el Ghazal	Sudan			
Sudd	Sudan			
Baro - Akobo - Sobat	Ethiopia	Details on data availability see below (Blue Nile)	Ministry of Water Resources Ethiopian Mapping Authority	
	Sudan	Administrative boundaries (2007) Hydrographic maps (Rivers, lakes, wetlands) Thematic maps (various parameters, recent) Hydroegological map (1:3.5 million)	Sudan Interagency Mapping	Remote sensing information is scattered
Lower White Nile	Sudan			
		Land cover, forestry zones, rainfall (1995-98, updated 2001)	Forests National Corporation	

Table 5.6 Spatial Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Content of GIS	Institution where data are available	Software used, Commentary
Blue Nile	Ethiopia	Different layers of spatial data, including land use/cover and soil maps 1:250,000	Ministry of Water Resources	Produced in the context of the Integr. Master Plan studies
		Topgraphic maps, aerial photographs, satellite imagery	Ethiopian Mapping Authority	
	Sudan	GIS map availability as described above. Inventory of hardcopy maps not available	Sudan Interagency Mapping	
Main Nile 4	Sudan			
Tekezze - Atbara	Ethiopia	Details on data availability see above (Blue Nile)	Ministry of Water Resources Ethiopian Mapping Authority	
	Eritrea			Information for Eritrea not available
	Sudan	GIS map availability as described above. Inventory of hardcopy maps not available	Sudan Interagency Mapping	
Main Nile 3	Sudan			
	Egypt	GIS maps - River and canal network, administrative boundaries, elevations, land use…	National Water Research Center, GIS Unit	
Main Nile 2	Egypt	Land cover/use (1:50,000) Topographic maps, aerial photographs Agricultural cadastral maps Geological maps (1:2,000,000)	Egyptian Survey Authority	Maps are also available from private companies, sometimes with additional information
Main Nile 1	Egypt			
		Geological maps	Egyptian Geological Survey and Mining Authority	

5.7 Water use data

Water use data need to be collected from the individual sub-sector stakeholders, and often the available statistics refer to production data (eg energy produced) or to area data (irrigated area) rather than to the actual water use; conversions are not necessarily straightforward.

The table below, which is based on existing reports and on fieldnotes from country assessments, lists important data providers but is by no means a comprehensive inventory of datasets and data sources.

Table 5.7 Water Use Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Sub-sector, Content	Institution where data are available	Software used, Commentary
Kagera	Burundi	Rural water supply (piped schemes, springs, wells, boreholes)	DGHER	Access database, not updatednventory underway with German support (2007)
		Agriculture: There are data on irrigated areas by commune (status 2004) but no detailed data on agricultural water use.	ISABU	Various formats

Table 5.7 Water Use Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Sub-sector, Content	Institution where data are available	Software used, Commentary
		Inventory of wetlands ("marais"), 2000	Centre for Environmental Information (CIE), Ministry of Lands, Environment and Tourism (MINATET)	Various formats
		Hydropower: Records of energy produced	REGIDESO – Energy Dept.	
		Industrial water use and effluents: not available		Very limited, agro-industry
		All sub-sectors (water supply, agriculture, hydropower)	Ministry of Energy and Mines - DGEE/DHR	Access database, not updated, status 1996
	Rwanda	Water supply: Data on water utilities, water production and consumption	Rwanda Utilities Regulatory Authority (RURA); ELECTROGAZ	ELECTROGAZ – Water will become RWASCO in 2008
		Agricultural water use: not readily available		
		Inventory of wetlands ("marais"), 2003: "Schéma directeur d'aménagement des marais"	Ministry of Agriculture	
		Hydropower: Data on energy production and consumption	ELECTROGAZ / national dispatching centre; in the future NEDA (National Energy Development Agency) will have a database	ELECTROGAZ – Energy will become RECO in 2008
		Industrial water use and effluents: not available		65% of industries located in Kigali
	Tanzania	Data on storage reservoirs in the Lake Victoria basin	Ministry of Water	
Lake Victoria	Tanzania	Irrigated areas	Ministry of Agriculture, Food Security and Cooperatives / Div. of Irrigation and Technical Services	Improved information management expected after the current reform
		Data on fisheries in Lake Victoria	Tanzania Fisheries Research Institute (TAFIRI) Fisheries Division of Ministry of Natural Resources and Tourism (MNRT)	
	Kenya	Water supply: Data on water consumption not available because of flat rate, no metering but historical data on water use is available with the MWI-National Water master Plan-after care, 1998	Water Service Board,	
	Uganda	Water supply coverage, gravity flow schemes	DWD	Excel, MIS under development
Victoria Nile	Uganda	Power supply and consumption	Ministry of Energy and Mineral Development	
		Irrigation schemes, potential for irrigation	Ministry of Agriculture, Animal Industry and Fisheries	

Table 5.7 Water Use Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Sub-sector, Content	Institution where data are available	Software used, Commentary
Semliki – Lake Albert	DRC	Water supply: Data on water infrastructure, data on water production, treatment and consumption	CNAEA (National Action Committee on Water and Sanitation), REGIDESO	Database under preparation at CNAEA
		Data on fishery in Lakes Edward and Albert are outdated	Ministry of Agriculture, Fishery and Animal Husbandry	Currently there is artisanal, unregulated fishery only
		No data available on other types of use		There is no irrigation in the Nile basin area
	Uganda	*Uganda (contd.)* Small dams and valley tanks	DWD, Rural Water Supply Dept. / Water for Production	
Albert Nile – Bahr el Jabal	Uganda			
	Sudan			Information for Southern Sudan to be compiled
Bahr el Ghazal	Sudan			
Sudd	Sudan			
Baro - Akobo - Sobat	Ethiopia	Information for Ethiopia see below (Blue Nile)		
	Sudan	Drinking water supply (processing plants, coverage at state level, etc.)	National Water Corporation	Information for Southern Sudan to be compiled
Lower White Nile	Sudan			
		Irrigation demand, irrigable areas, drainage, reservoir operation	Ministry of Irrigation and Water Ressources, Irrigation Services Directorate and Dam Directorate	
		Hydropower	National Electricity Corporation, Electricity Regulation Authority	
Blue Nile	Ethiopia	Hydropower potential Irrigation potential	Results of Integrated River Basin Development Plans available at Ministry of Water Resources	Information sources on water use in Ethiopia to be completed.
		Agricultural statistics	Central Statistical Agency, Regional Bureaus of Agriculture	
	Sudan	Information sources for Sudan as described above		
Main Nile 4	Sudan			
Tekezze - Atbara	Ethiopia	Information for Ethiopia see above (Blue Nile)		
	Eritrea			Information for Eritrea not available
	Sudan	Information sources for Sudan as described above		
Main Nile 3	Sudan			
	Egypt	Date related to Assuan High Dam and reservoir lake, including hydropower generation	Aswan High Dam (AHD) Authority	Approval required for release of data

Table 5.7 Water Use Data Availability by Sub-basins and Countries

SUB-BASIN	COUNTRY	Sub-sector, Content	Institution where data are available	Software used, Commentary
Main Nile 2	Egypt	Water infrastructure operation, storage and diversion schemes	MWRI, Reservoirs and Ground Barrages Sector	Release of data subject to approval / data exchange arrangements
		Hydropower generation		
		Irrigated area, discharges of irrigation canals	MWRI, Irrigation Sector	
Main Nile 1	Egypt			
		Navigation	River Transport Authority	
		Industries, wastewater discharge	Environmental Inspection Unit (EIU	

5.8 Conclusions: Data availability from the perspective of NBI-DSS development

Hydro-meteorological data availability is not satisfactory for the purpose of NBI-DSS development and operation. There are few countries with adequate operational monitoring networks. Most hydro-meteorological services encounter serious operational difficulties (mostly related to a lack of recurrent budget for proper network operation), and this seriously affects data reliability and availability (use of outdated rating curves, delays in data processing). In certain parts of the Nile basin – Rwanda, DR Congo, probably Southern Sudan) – hydrological data collection has completely stopped. Telemetry is hardly used in most of the Nile basin countries, with the exception of Egypt; real time data are therefore not available.

While this situation needs to be taken into account in the DSS design these facts should not delay the activities related to DSS development or put its feasibility into question: A DSS can be developed using historical data and expert assumptions combined with known concepts and algorithms.

None the less, WRMP should undertake determined efforts to support the generation of reliable hydro-meteorological data for DSS development, model calibration and operational use. Liaison with NBI SAP projects is essential in this context, in order to mobilise investment funds and ensure consistency of the data collection and information systems which are under development.

The recommended measures are:

- Define a core network of NBI-DSS stations of regional importance. These stations should be linked to a NBI telemetry system which would be a key source of input data for an operational NBI-DSS. Data quality should be excellent, with supervision (quality assurance) provided at the regional or sub-regional level.
- Mobilise support for the re-establishment of hydro-meteorological services, in particular in post-conflict countries (Burundi, Rwanda, DR Congo, Sudan); this could be done through SAP projects or by facilitating support from other agencies or international organisations.
- Sensitise national authorities to provide adequate means (recurrent budget) for keeping the hydro-meteorological services operational and producing reliable data.
- Promote the introduction of automated stations combined with telemetry equipment. This would have a number of significant advantages, including better data resolution (eg hourly data during floods), automated processing, prompt information about station failures at the centre, and real time data availability (for forecasting purposes). However, conventional equipment (such as staff gauges and raingauges) needs to be kept in

parallel as a more robust fallback solution if the modern equipment fails (due to energy failure, theft, etc.)

- Promote an integrated approach where all data that are relevant for decision making in water resources management are centralised in a river basin agency (similar to the model implemented in Kenya).
- Initiate and encourage data exchange arrangements and data harmonisation efforts.

Particular efforts will be required, in the context of NBI-DSS development, to compile and analyse those types of data that are typically scattered and not available through remote sensing:

- Groundwater data
- Water quality data (surface water and groundwater quality), including sediment transport data

There are few regular monitoring activities in these fields. Data are often not inventoried and often available from temporary (measuring or drilling) campaigns and project reports only.

Spatial data for the NBI-DSS will be constituted partly from remote sensing information available from international or regional sources, and partly from GIS data available at the national level. The use of national sources is not always straightforward as the data formats, reference grids and quality standards used vary considerably. The use of remote sensing data will be essential to close the gaps between the measuring stations (as the hydro-meteorological network densities will not be according to international standards in the near future), to assess spatial features (in particular topography and land use/cover) and for forecasting and scenario definition purposes (link to regional climate models).

The availability of demographic and socio-economic data is satisfactory for all Nile basin countries except for Burundi, DR Congo and Sudan where the older surveys and censuses cannot be extrapolated due to recent instability. However, in all three countries new censuses to establish the post-conflict situation are planned and it is likely that, during DSS development, adequate data will become available. Data are relatively easy to obtain from national agencies (bureaus of statistics). In some cases public health data (in particular epidemiological data) need to be compiled from the competent Ministry of Health departments.

Water use data normally need to be collected from the individual sub-sector stakeholders, and a comprehensive inventory of datasets and data sources is not yet available.

6 Model Availability and Use

This section is by no means a comprehensive or exhaustive listing of all available models within the riparian countries of the Nile Basin. It is however a compilation of the most relevant models that can serve as Decision Support System tools in the planning and management of Nile Waters at the basin-wide transboundary level, and that can support the analysis and evaluation of joint projects within the Nile River basin. The Consultant has received information to varying extents from the Nile Basin countries so far, additional information needs to be collated during the Analysis Phase.

6.1 Models in Ethiopia

HEC-5 / HEC-ResSim

In Ethiopia, HEC-5, a precursor to the HEC-ResSim simulation model has been used to improve operating rules for the Koka Dam on the Awash River (Seleshi 2006).

Table 6.1 Models in Ethiopia

Themes or sector(s) concerned	Model Name	Type	Application Region
Hydrology	MIKE BASIN 2001	Rainfall-Runoff	Wabi-Shebele Basin
Hydrology	RIBASIM	Rainfall-Runoff	Tekeze River Basin
Hydrology	WATBAL	Rainfall-Runoff	Abbay River Basin
Hydrology	SMS	Sediment Transport	Upper Awash River
Hydrology	FEWS	Flow simulation	Awash Basin
Water Resources Management	WEAP	Risk Assessment Model	
Water Resources Management	WMS	Rainfall-Runoff	Upper Awash River
Soils and Erosion	AGNPS Agricultural non-point source model	Soil erosion & pollution model	Ethiopian highlands

6.2 Models in Egypt

This section is by no means a comprehensive or exhaustive listing of all available models within the riparian countries of the Nile Basin. It is however a compilation of the most relevant models that can serve as Decision Support System tools in the planning and management of Nile Waters at the basin-wide transboundary level, and that can support the analysis and evaluation of joint projects within the Nile River basin.

In Egypt, within the Ministry of Water Resources & Irrigation there are several models that have been developed and are in use. The operation of HAD and the Old Aswan Dam (OAD) is optimized for different operation scenarios using the Decision Support System for High Aswan Dam **(HAD-DSS)** which utilizes forecasts from the NFS (or other sources) and study the impacts on energy production and release policies of the HAD.

The **Rainfall Estimation Model** receives three different spectral bands of satellite images that are infrared, visible and water vapor. The Model is mainly based on cold cloud duration and cloud top temperature with different manipulation of parameters. Currently, infrared cloud top temperature data obtained from the European Space Agency (ESA) geostationary METEOSAT 5 satellite positioned over Africa is the primary data utilized in preparation of the precipitation estimates. Surface observations of precipitation obtained from the Global Telecommunication System (GTS) of World Meteorological Organization are the secondary data type utilized in the scheme.

There is also the **MESO-ETA Model** Application. The ETA model is a 50-layer model with 29 km resolution. Initial conditions come from the EDAS. The Meso-ETA became operational in early 1995 and produced 33-hour forecasts twice per day. In 1995, the Meso-ETA began to run four times per day. After the arrival of the Class VIII system, an increase in the horizontal resolution of the Meso-ETA to 15 km and the number of levels to 70 was reached.

The **Hydrological Simulation Model** component simulates the entire river system using a variety of hydrological distributed models: water balance, hill slope and channel routing, lake, swamp, reservoir, reach routing, and stochastic. The METEOSAT coordinate system is used as a basic mapping system with a basic resolution of 1 pixel (5x5 km at the sub-satellite point). The Simulation is maintaining standard simulated soil moisture, hillslope and channel flow states corresponding to the available precipitation estimates and is called with varying inputs by other modules to determine the effects of various future precipitation scenarios on discharge, facilitating the generation of hydrological forecasts.

The **National Forecasting System (NFS)** is a distributed modeling system that divides the basin into grids. It is a grid-based soil moisture account model that calculates the discharge of the Nile and its tributaries on a daily time step. It is based on the quasi-rectangular grid at the METEOSAT satellite projection (average grid cell size is 5.5 x 5.5 km). In brief the MWRI hydrologic model for the Nile system includes a grid-based hydrologic model. For each grid cell (approximately 30 km^2 in size) the transformation from rainfall to runoff is simulated by a water balance model, a hill-slope routing model, and a channel routing model. The water balance models the rainfall-runoff process in the soil. It has two layers which represent a shallow, fast-flowing upper (surface) soil zone and a slower lower (groundwater) soil zone. The outflow is the total runoff (in mm) which is a combination of the surface and groundwater runoff. The hillslope model serves to rout the runoff from the water balance runoff over land to the channel, effectively producing a time lag and some attenuation for the local runoff within a pixel. The channel routing model routes water from pixel to pixel and cause both a time lag and attenuation of the flow as it moves downstream.

There are two **Forecast Modules**:1) The Extended Streamflow Prediction (ESP) Forecast module and 2) the Deterministic Forecast module. Each module runs the forecast component a number of times for the same future dates, starting with current simulated state variables for the hydrological system but with different values for future precipitation. The ESP module uses precipitation values for historical years; the deterministic module uses fixed percentages of climatological precipitation. The various future discharge traces produced by the forecast component runs are analyzed to give a probable future discharge-time curve and a corresponding envelope of uncertainty. The objective of the ESP model is to provide a reliable streamflow forecasting capability to support improved operations of the HAD.

The **High Aswan Dam Decision and Control System** is a module utilizes Dynamic Programming as the optimization procedure on different tradeoffs (spillage versus energy, evaporation versus energy …etc.) to provide an optimal relationship among total system outflows, total hydropower plant load, and reservoir elevation. As an input, it takes a set of ESP forecasted traces for the profile at Dongola which is considered as an inflow profile for the Lake Nasser. The output is serving as a support for the operational management of the High Aswan Dam.

The **Nile Basin Hydro-meteorological Information System** (NBHIS) presents one of the most important modules of the NFC. It contains on-line hydrological and meteorological data base consisting of: 1) daily and monthly river stages and discharges, reservoir elevations and releases for many profiles along the Nile river for the longest possible historical record, and 2) daily meteorological data (temperature, dew point, wind, visibility and precipitation) for about 100 observational stations inside of Nile catchment since year 1992, and historical monthly precipitation grids for the period since 1940 to date. These data are used as inputs to the meteorological and climatological analyses, and to the hydrological simulation and forecasting system, for the calibration, and to allow the user to perform and evaluate simulation runs for historical period. The database additionally forms a resource on its own, accessible through the user interface.

There is a **GIS database** is primarily used by the user interface to augment displays with a geographical context. This database is also accessed by the forecast component to obtain information about elevations, channel connectivity, etc. The NFS depends on a large hydro-meteorological database (possibly the largest in all Nile Basin countries) which includes:

- Meteorological data including raw and processed METEOSAT Satellite images as well as rain-gauge data, temperature, pressure, humidity for a number of gauging stations covering the Nile Basin.
- Hydrological data including daily river stages and discharges at key stations along the river in addition to operating rules for existing reservoirs on the Blue and White Niles
- Soil Data sets (type, characteristics, properties …etc).

A considerable effort has been done by the NFC to gather different kinds of data sets that help in calibration and validation of different implemented models within the system. Examples of these data sets are:

- Satellite images (Infrared, Water Vapor and Visible images) that are received daily through the implemented system.
- Climatological data for all Nile Riparian countries. These data are downloaded and decoded then amended to update the data base. These data include rainfall, due point, temperature, cloud cover, humidity rate… etc. these data together with satellite images are used to estimate rainfall over the Nile catchments area.
- Observed levels, flows, reservoir releases, levels at different locations along the Nile.
- GIS data the includes soil type, elevation, main schematic of the river Nile, minimum, maximum and mean elevations, soil types and unit soil profile thickness, water storage, soil texture, water storage at root level, soil vegetation index, and ecology.
- Climatological data the includes maps for average monthly precipitation, average precipitation for rainfall season months, average annual and monthly potential evapotranspiration, different statistical maps for precipitation.

The models that are used at the Ministry of Water Resources & Irrigation (MWRI) have several uses in producing <u>operational outputs</u> such as:

- Daily rainfall estimation maps that represent rainfall distribution over the various sub-basins.
    - Two weekly meteorological bulletins (in Arabic) that describe the rainfall and meteorological conditions along the Nile sub-basins together with extended forecast for expected rainfall over three days in advance.
    - Decadal bulletin (in Arabic) that summarizes the metrological and hydrological conditions over the Nile sub-basins. This summary is accompanied with graphs that represent the observed data compared with absolute maximum, absolute minimum, maximum years, minimum years, and average values. The purpose of these graphs is to have a feeling of the existing conditions compared to the conditions that happened before. Also the bulletin

updates issued forecasts in pervious bulletins, sets some warnings (if necessary) for decision makers to take certain actions towards the operation of HAD. The importance of such bulletins appears more in severe flood years or drought years and also in cases when the HAD lake is full or about to be low.

- Monthly bulletin (Arabic and English). This bulletin represents a comprehensive summary of the flood season since its start.

These MWRI-NFC models also produce other non-operational outputs that support decision makers in trade-off analysis and quantification of the benefits and consequence of initiating any projects along the Nile.

These are sample of questions that the MWRI-NFC can answer with a considerable reliability:

- What is the short-term effect of a severe rain event?
- What is the hydropower potential of various proposed projects along the Nile Basin?
- To what degree can such projects regulate the flow of the Nile?
- Can such project create conflicts between local and downstream interests?
- Are there Win-Win projects and what are the benefit and impacts on riparian countries?
- What would be the conditions of Lake Nasser and HAD if severe floods come in consequent years?

In addition to the periodical bulletins issued by the NFC, different scenarios for future floods can be analyzed based on the current boundary conditions. The results of these analyses are discussed with top-level management, and then submitted to decision makers in order to assist in developing operating rules of the HAD, as well as the water resources management plans.

On the other hand, the potential activities using available and other modeling needs at the NFC include:

- Harmonization and cooperation in forecasting and water resources modeling between Egypt and other riparian countries.
- Assessment of climate change impacts on the Nile Basin riparian countries.
- Development and improvement of operation strategies for Lake Nasser.
    - Supporting riparian countries in scenario analysis and joint project evaluation under the umbrella of the Nile Basin Initiative (NBI).

Another model that is being used in Egypt is the **Egyptian Water Resources, Socioeconomic and Environmental System (EWRSES)-DSS**, which is a DSS that enables Decision and Policy Makers to perform an integrated evaluation of alternatives of National Water Resources Plans under an integrated and dynamic perspective. The DSS is intended to produce information useful for evaluation of alternative Water Resources Plans under given (guessed) scenarios. This functionality allows the DSS-User to browse among all data defining the Egyptian Water Resources, Socioeconomic and Environmental System (EWRSES), like irrigation and drainage networks, Spatial Units, Governorates, climatic regions, population, cropping pattern, etc..

It includes also the capability to assess the current state of the EWRSES through static relationships among data, in order to answer queries like: how do crops perform with respect to given -flexibly definable- criteria (e.g. identifying what crop is responsible for the maximum fertilizer consumption per unit of income generated, etc.); The DSS can help in the definition of the *scenarios* (e.g. population growth, hydrological climate induced changes, non-scheduled implementation of development projects); as well as representing alternative development measures like development projects (e.g. Toshka project, Salam canal, Jongley canal), multi-annual plans (time scheduling of projects), policies (incentives-restrictions to drainage water re-use, cropping, settlement, etc.), different management policies for Lake Nasser, or a combination of them (*Water Resources Plan Alternative*).

Water Resources Management Decision Support System (WRMDSS)

This DSS includes a Multi-Criteria Evaluation techniques coupled with an Expert System and a GIS (AbuZeid, K. 1998). It evaluates different cropping patterns based on criteria set by experts to mimic how they would evaluate different agriculture strategies based on its economic, social, environmental, political, and technical impacts. It has been applied to the Eastern Nile Delta of Egypt.

Environmental Impact Assessment Decision Support System (EIADSS)

The CEDARE Environmental Impact Assessment Decision Support System (CEDARE-EIADSS) for irrigation projects developed by Abu-Zeid, K. & Bayoumi, M. (1999) for the Centre for Environment & Development for the Arab Region & Europe (CEDARE), is a Personal Computer model operating under Windows environment. It was developed for the comparison between irrigation project alternatives based on all relevant aspects of the surrounding environment of an irrigation project. It is intended for use by specialists or non-specialists high-level decision-makers.

Inputs to the EIADSS include selected answers for a set of multiple choice questions that provide sufficient information to describe the baseline conditions and the general design for several project alternatives. An Expert System was built into the EIADSS to translate the multiple choice answers to positive and negative scores reflecting the expected impact. Other inputs to the EIADSS include estimated parameters required to calculate economic indicators. On the other hand, the EIADSS outputs, in the form of positive and negative scores, allow the user to evaluate different impacts criteria on neighbouring and project areas. The different criteria impacts are categorised as Natural Resources, Biological Life, Socio-Economics, Political, and Economics impacts. The user is also required to input importance weights to these categories of impacts. The final output is an overall environmental index for each project alternative. The EIADSS is an efficient tool for supporting the decision making process, especially in the trade-off between project alternatives according to anticipated environmental impacts including economic aspects. Although this EIADSS was developed for irrigation projects applications, the software was designed in a flexible manner to allow for future adaptation to other applications using the same technique.

Integrated Water Resources Model for Sustainable Development (IWRMESD)

IWRMESD (Integrated Water Resources Model for Egypt's Sustainable Development) has been developed in the River Nile Protection and Development Project (Nile Water Strategic Research Unit, 1997) with CIDA assistance. It is a tool to simulate and evaluate different alternative water resources scenarios for Egypt. The model distinguishes five main socio-economic sectors: agriculture, industry, domestic, power generation and navigation. Within these sectors sub-sectors are distinguished. For example, agriculture is split into the new and old land sectors, because of the significant difference in characteristics with respect to cropping pattern, soil type and irrigation system.

The main objective of iwrmesd is to assess water policies formulated to satisfy the long term socio-economic plans on the national level in the five sectors. Model input variables are policy variables which are controlled by the MPWWR (such as related to water supply or waste water treatment), policy variables which are not controlled by MPWWR (for example cropping patterns, industrial growth), and non-policy variables (for example use of agro-chemicals, crop productivity, etc.). Water policy assessment is carried out using several indicators in the areas of water availability, ecosystem quality, social living standards and economic growth. The model time step is one year. No geographical distribution is assumed and the entire country is modelled as one geographic unit.

Nile Basin Simulation Model (NBSM)

NBSM is a strategic planning tool developed by Mott MacDonald for the Nile Security Project funded by World Bank/UNDP (Mott MacDonald Int. Ltd., 1992). The model simulates 20 years of water management and operation for the Nile system downstream of Lake Nasser (schematised into 11 areas), taking into account possible developments in the Upper Nile basin (such as the Jonglei canal). The user can set a wide range of parameters covering irrigation areas, cropping patterns, irrigation efficiencies, demands for sectors other than agriculture, reservoir operating rules, etc. and run the model for a range of Lake Nasser inflow scenarios.

The output of the model contains information about the water- and salt balance, water shortages, and agricultural production.

River Basin Simulation Model (RIBASIM)

RIBASIM is a generic model package developed by delft hydraulics for the simulation of river basins and water distribution systems. It is a comprehensive and flexible tool to link the inputs of water with the various water demand sectors. The model is ideally suited to assess the potential for development or to assess impacts of measures to improve the water supply and distribution. RIBASIM has been adopted as standard software by Water Resources Agencies in many countries.

RIBASIM simulates the water balance and water allocation, taking into account the hydrodynamic characteristics of the river system, water demands and availability, operation rules of major structures, and allocation priorities. To compute the water demands a number of demand modules are available: AGWAT for agricultural demand and FISHWAT for fresh water demands of brackish water aquaculture. Municipal and industrial demands are usually entered as fixed demands, either with or without a seasonal fluctuation.

The model makes use of a schematisation in the form of a network, consisting of nodes connected by branches which represent the transport of water between the different nodes. The following main groups of schematisation elements are distinguished in the model:

- Natural and man-made infrastructure (for example reservoirs, rivers, canals, pump stations, pipelines, etc.);
- Water users (agriculture, municipal and industrial, hydropower, etc.).

In the water distribution, specific water management policies can be accounted for through, for example, operational rules, supply priorities, proportional water allocation, and minimum flows in certain river stretches for navigation or for sanitary or ecological purposes.

The existing water related infrastructure is schematised for model calibration and simulation of the present situation. Thereafter, the already planned or ongoing structural developments are schematised to reflect the base case condition in the planning horizon. Additional infrastructural or operational measures may be added to simulate their impacts on the water demand and supply conditions in the future. The simulation results can be processed with a number of standard post-processors into graphs, maps and tables.

For each time step of the computations, a water balance calculation is made. This is done in two phases: the target setting (demand) phase and the water allocation (supply) phase. In case of shortages in agriculture or aquaculture, the actual yields will differ from the potential yields. Actual yields are computed in the wadis-2 post-processor.

Planning and Distribution Model (PDM)

The Planning and Distribution Model, now also called OPDM (Operation and Planning Distribution Model), was developed by Utah State University in co-operation with the Planning Sector within the framework of the Planning Studies & Models project (USU/MPWWR, 1995; Hatim, 1996). PDM is a network type model similar to RIBASIM that can be used to simulate water demands (agriculture, domestic and industrial) and supply. Also similar to RIBASIM is the possibility to create the network schematisation interactively via the user interface. The model structure allows schematisations at different levels of aggregation. The model can estimate actual crop yields in relation to water shortages, soil water salinity, and water logging. However, this is only possible if the model is used for a detailed schematisation of for example an irrigation scheme. For use of the model at a higher aggregated level such estimations are not realistic.

Simulation of Water Management Model (SIWARE)

The SIWARE (Simulation of Water Management in Arab Republic of Egypt) model system, developed by the Staring Centre in co-operation with DRI, is used to simulate the effects of changes in the agricultural water management in the three parts of the Nile Delta (DRI / Staring Centre, 1993 and 1995; Sijtsma, B.R., et.al., 1995). The area is divided into calculation units with more or less homogeneous soil type. Water demand for M&I supply can be added to the agricultural water demand. The model contains the following modules:

- The design module describes the distribution of the available Nile water among the intakes of the main canals on the basis of agricultural and M&I water demand;
- The WDUTY module computes water requirements of all crops in each calculation unit on the basis of potential evapotranspiration and crop type;
- The WATDIS module computes the actual water distribution between the calculation units on the basis of computed demands;
- The REUSE module computes evapotranspiration, percolation and seepage, drainage from agriculture, and official and unofficial reuse of drainage water.

Actual evapotranspiration is computed from the evaporative demand and actual soil moisture content and salinity in the root zone. Also, the salinity of the drainage water is calculated. The model has been used to assess the effects of:

- Changes in drainage water reuse, for example by constructing additional reuse pump stations;
- Changes in cropping patterns (for example the replacement of rice with other crops);
- A reduced fresh water input from the river Nile.

SIWARE is used as the water demand and supply model in the Decision Support System which were set-up for the Western, Middle and Eastern Delta (see also Section 2.3) in the MADWQ project at DRI. In these Decision Support Systems SIWARE is applied in combination with the water quality model DELWAQ and the emission model WLM.

NWRP-DSS

The NWRP-Decision Support System (NWRP-DSS) is the main planning tool to assess the impacts of different strategies on the water resources system for a selected combination of demand and supply scenarios. An important feature of the dss is that it enables the planners to quantify a large number of parameters in the water resources system, both for the present situation and for potential future situations. It facilitates the complicated process of comparison between strategies with many variables.

The DSS consists of a set of databases, models and tools for simulation and analysis and presentation of results. The databases mainly contain model related data, such as time series on cropping patterns and water quality monitoring, and data that describe the characteristics of the water resources system

The DSS includes the following simulation models:

ASME model which determines the optimum cropping pattern and other agro-economic and socio-economic parameters; RIBASIM and SIWARE models which simulate the water demands and water distribution; WLM and DELWAQ models which simulate the waste loads and the surface water quality Groundwater models which simulate the groundwater behaviour of the Nile aquifer in the Valley and Delta.

ASME is used to determine the optimum cropping pattern, given certain constraints related to available water, size of irrigation areas, demand for agricultural and livestock commodities, external trade, etc. This cropping pattern is passed off-line to the water distribution models that are incorporated in the DSS-Nile and the DSS-Delta to compute the irrigation requirements and, based on available water and supply priorities, the water distribution.

The DSS-Nile includes the Nile plus its Rosetta and Damietta branches. The dss-delta operates at a more detailed level and includes the Western, Middle and Eastern Delta plus connected horizontal expansion areas. A full integration of these DSS's was not considered useful because it would require a major programming and schematisation effort. Furthermore, such complex system would be less flexible.

The water distribution models and the water quality models are core models that are integrated in both the DSS-Nile and DSS-Delta. This integrated approach to water management significantly simplifies the decision-making. The water distribution models RIBASIM and SIWARE are used in the DSS-Nile and DSS-Delta, respectively. For water quality the waste load model WLM and the water quality model DELWAQ are used in both DSS's, which also include a coin-model for the economic analysis of wastewater treatment plants. Whereas the DSS-Nile is operated at the Planning Sector of MWRI, the main expertise on the DSS-Delta is with the Drainage Research Institute (DRI) of the NWRC. For adaptation of the DSS-Delta on behalf of the NWRP, the NWRP-project closely co-operated with the MADWQ project at DRI.

The groundwater in the Nile Valley and Delta forms an integral part of the Nile system. To study the interaction between the surface and groundwater sub-systems two groundwater models were developed by RIGW: one for the Valley and one for the Delta. These models are steady state models that give a general insight in groundwater potentials, groundwater related problems, impacts of specific measures on groundwater levels and resulting recharge/seepage rates.

To evaluate impacts of potential strategies on specific policy objectives, indicators have been defined. The value of each indicator for different situations can be visualised on score cards.

6.3 Models in Kenya

Table 6.2 Models in Kenya

Themes or sector(s) concerned	Model Name	Type
Climate	SpatRain	See Baseline Study page 34
Hydrology	GenRiver Generic river flow model	See Baseline Study page 34
Soils and Erosion	WaNuLCAS Water, Nutrient and Light Capture in Agroforestry Systems	See Baseline Study page 34
Soils and Erosion	SExI-FS Spatially Explicit Individual-Based Forest Simulator	Sediment Transport
Land use/cover	Fallow Forest, Agroforest, Low-value Landscape or Wasteland	Flow simulation

6.4 Models in Sudan

Table 6.3 Models in Sudan

Themes or sector(s) concerned	Model Name	Type	Application Region
Water balance/scarcity/drought s	Blue Nile Water Balance Model [1)]	Water Balance Model	Blue Nile Basin
Flood protection/river training	SFEWS Flood Early Warning System	Risk Assessment Model	Blue Nile, Atbara River, the White Nile downstream of Malakal and the Main Nile up to Dongola

[1)]currently being used to estimate inflow to the Blue Nile at boarder (Eddeim) using water balance at Roseires Reservoir (by Dr. Osman El Tom and Eng. Abbas Hydayt Alla)"

6.5 Models in Tanzania

Water Evaluation and Planning Model (WEAP)

WEAP is a simulation model that can simulate sectoral water demand, water conservation, water rights and allocation priorities, stream flow simulation, reservoir operation, ecosystem requirements, and project cost-benefit analyses (Stockholm Environment Institute, 2005). The model has been used to assess scenarios for water resources development in the Pangani Catchment in Tanzania (King pers. comm.. 2006).

Table 6.4 Other models in Tanzania

Themes or sector(s) concerned	Model Name	Type
Hydrology	SMAR Soil Moisture Accounting and Routing Model (SMAR)	Rainfall – Runoff Model (Water balance Model)

Purpose: Simulates run-off from rainfall and climatic input (mainly used for teaching)
Spatial Resolution: Catchment
Time Step: Daily
Input: Rainfall, Evaporation and River Discharges
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: University of Dar Es Salaam

Hydrology	LPM Linear Pertubation Model	Rainfall – Runoff Model

Purpose: Simulates run-off from rainfall, filling missing data and forecasting (Mainly used for teaching)
Spatial Resolution: Catchment
Time Step: Daily
Input: Rainfall and River Discharges
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: University of Dar Es Salaam

Hydrology	ANN Artificial Neural Network Model	Rainfall – Runoff Model

Purpose: Simulates run-off from rainfall (Mainly used for teaching)
Spatial Resolution: Catchment
Time Step: Daily
Input: Rainfall, Evaporation and River Discharges
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: University of Dar Es Salaam

Hydrology	FEWS Famine Early Warning System	Rainfall – Runoff Model

Purpose: Simulates rainfall run-off process
Spatial Resolution: Grid
Time Step: Daily
Input: Rainfall , Evaporation, DEM, Soil, Land cover/Land use
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: University of Dar Es Salaam

Hydrology	SMAP	Rainfall – Runoff Model

Purpose: Simulates run-off from rainfall and climatic input, extends flow records, fills missing data and generate flows in ungauged catchments (conceptual)
Spatial Resolution: Catchment
Input: Rainfall, Evaporation and River Discharges
Output: Runoff
Developed by: LVEMP,LVBWO

Water balance/scarcity/droughts	PITMAN	Water Balance Model

Purpose: Simulates run-off from rainfall and climatic input, filsl in missing data, extends flow records and generates flows in ungauged catchments
Spatial Resolution: Catchment
Time Step: Monthly
Input: Rainfall and Evaporation
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: PWBO

Water balance/scarcity/droughts	HBV	Water Balance Model

Simulate run-off from rainfall, climatic inputs and snow melt
Spatial Resolution: Catchment
Time Step: Daily

Input: Air temperature, Rainfall/Snow melt/accumulation, Evaporation and River Discharges
Output: Runoff, Coefficient of Efficiency (R2)
Developed by: University of Dar Es Salaam

Surface water quality	STELLA	Eutrophication Model

Purpose: Nutrient transformation and removal model, Water quality management and design
Spatial Resolution: Any scale (micro to meta)
Time Step: Hourly, daily etc of (N – species)
Input: Nitrification rate, denitrification rate, volatilization rate, sedimentation rate
Output: (N –Species)
Developed by: University of Dar Es Salaam

Surface water quality	QUAL2	Water quality management model

Purpose: Predicts changes in water quality
Spatial Resolution: Meso scale
Time Step: Daily, weekly, monthly, yearly
Input: Nitrification rate, denitrification rate, sedimentation rate, decay rate
Output: Water quality parameters (BOD5, N, P etc)
Developed by: University of Dar Es Salaam

Surface water quality	DUFLOW	Wetland water quality model

Purpose: Model removal of pollutants in wetlands (buffering capacity of wetlands)
Spatial Resolution: Wetland
Time Step: Daily
Input: Sediment and nutrient loads
Output: Sediment and nutrient loads
Developed by: LVEMP

Water Resources Management	SWAT Soil Water Assessment Tool	Watershed Model

Purpose: Simulates rainfall run off, sediment yield, erosion, predicts reservoir sedimentation and dry spell analysis.
Spatial Resolution: HRU's (Hydrologic Response Units)
Time Step: Daily
Input: Climate, topography, vegetation, land use, soil, stream flow
Output: Runoff, Sediment yield (sedigraph), Time integrated yield, Erosion rate, soil water content and water quality
Developed by: University of Dar Es Salaam

6.6 Regional Models in the Nile Basin

Nile Decision Support Tool (Nile-DST)

The Nile Decision Support Tool has been developed as part of the Nile Basin Water Resources Project under the auspices of the Food and Agriculture Organization of the United Nations (FAO), in collaboration with the Nile focal point institutions. The model purpose is to assess the benefits and tradeoffs associated with various basin wide water development and management options. Recently, the development of the Nile-DST was transferred to the WRPM project. The Nile DST includes six main components namely: (1) database; (2) river simulation and management; (3) agricultural planning; (4) hydrologic modeling; (5) remote sensing; and (6) water quality. Each component has been described in detail in separate technical reports and user manuals (Georgakakos 2006).

Lake Victoria Decision Support Tool (LVDST)

The LVDST is a combination of models and a database to support long term planning and short term operation of Lake Victoria reservoirs and hydropower units. It allows for hydropower production optimization within long term planning decisions. (Georgakakos, 2006)

6.7 Other regional Models in Africa

Other non-Nile basin DSS-related models that were cited and may be relevant to the work on the DSS in the Nile Basin include but are not limited to the following:

GLOWA Volta DSS for the Basin

It is an information system developed as part of the GLOWA Volta Project to provide decision support for the planning, management and use of water resources in the Volta Basin. It includes an optimization model which represents the decision rules and constraints of water users, the physical water system. And production functions (GLOWA Volta, 2006).

DSS for Komati Water Resources Planning

The Komati Basin Water Authority (KOBWA) plans and manages Dams in the Komati river basin shared between South Africa, Mozambique, and Swaziland using a suite of three DSSs. These are for water allocation, water rationing, and river hydraulic application (Dlamini, 2006).

Decision Support System for the Senegal River Delta

The hydrodynamic model, Mike 11, has been used with a digital elevation model to assess hydraulic impact of different release regimes on the Senegal River Delta and implications on the ecology and the livelihoods of the people (Duvail and Hamerlynck 2003, 2007).

Kafue DSS

The hydrodynamic model (KAFRIBA-Kafue River basin) has been developed to improve the operation of dams located on the Kafue River, Zambia. Used in conjunction with improved forecasting of flows, the DSS enables the Dam operator (Zambia Electricity Supply Corporation) to make decisions on releases in a way that balances hydropower with other water uses and protection of the ecology (DHV Consultants, 2004).

Global Water Availability Assessment (GWAVA) model

This model assesses water availability on a catchment scale using hydrology modeling and GIS in terms of water supply indices versus water demand. It enables impacts of climate, population, and land uses change to be investigated. It has been used to simulate regional water resources across eastern and southern Africa and more specifically in Swaziland and the Okavango Delta (Tate et al. 2002).

6.8 Other regional models outside Africa

The Mekong Decision Support Framework (DSF)

The DSF is a comprehensive system that includes three detailed simulation models; of the Lower Mekong Basin (LMB) subcatchments, the river network, and the uniq floodplain system below Kratie, including the Great Lake and Mekong Delta. These simulation models can provide detailed statistical information on the daily distribution of water anywhere in the land or rivers of the LMB, and salinity intrusion in the Mekong Delta for a period of up to 16 years. These simulation models can then be used by a Business Development Plan (BDP) to estimate changes in distribution that may result from a country's development plan, including impacts on other countries and sectors. This information is then made available to managers and decision-makers to assist their choices regarding the development options and scenarios that are most likely to achieve an optimal balance between environmental and socio-economic outcomes.

The BDP works hand-in-hand with the different Mekong River Commission (MRC) programmes: - Water Utilisation, Environment, Flood Management and Mitigation, Fisheries, Navigation and Agriculture, Irrigation and Forestry – incorporating information from these into the Decision Support Framework (DSF).

At the end of the BDP process, governments will have access to scenario-based information that will enable decisions to be made within a range of acceptable choices. It will be possible to assess whether the water resources plans of the four countries of the MRC are compatible, with sufficient water in the system to meet all planned uses. Various development options can then be compared and ranked once the trade-offs resulting from different levels of social, economic and environmental impacts are analysed and understood (www.mrcmekong.org accessed September 2007).

7 Water Availability

7.1 Climate

7.1.1 General

The north–south orientation of the River Nile on the African continent means that the exteme ends of the basin are subject to serious 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.

In an average year the basin receives some 650 mm of raingfall corresponding to around 1,900 bcm of water per year. Long-term mean annual flow at Aswan is only about 85 bcm per year, making the annual runoff coefficient of the basin around 4.5% (Nicol 2003). This figure is small and, for example, is just 10% of that of the Rhine. This is explained by the fact that a signficant 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 which cause up to 30% of the basin's rainfall to be lost before being used for any purpose. On the Ethiopian massif, the key contributor of Nile flows, the kiremt rains produce the main June to November spate. This spectacular phenomenon is the combination of three mechanisms: the northward movement of the Inter-Tropical Convergence Zone (ITCZ) (summer monsoon) over the highlands, before retreating again, the tropical "upper easterlies," and local convergence in the Arabian Sea region. The resulting rainfall is often intense, and causes rapid runoff leading to major soil loss (Nicol 2003). In the south precipitation is also stormy and caused by convection, orthographic conditions or frontal conditions caused by the collision of dry north east boreal winds with the moist air above the Indian ocean being blown in to the region from the South.

Rainfall expectations for each of the sub-basins delineated in Section 1.1 are considered in the following sub-section.

7.1.2 Rainfall

In general terms and as was clearly illustrated in Figure 2.4, the northern third of the basin, with the exception of the coastal margins of the Main Nile 1 sub-basin, effectively receives negligible rainfall. The same figure shows that, with some small expections, the remainder of the NB receives rainfall on a seasonal basis; the exception being the very eastern margins of the basin which has the possibility of rainfall throughout the year. For the remainder of the area in question, and with minor exceptions, there is a single rainy season which varies with lattitude in terms of both timing and duration - Figure 7.1 refers. In the Equatorial Lakes region, the rainy seasons usually have two distinct peaks, one more signficant than the other while in some parts of Ethiopia, in some years a minor peak occurs between February and March - Figure 7.2 refers.

As suggested above, quantitative rainfall expections also vary across the basin and are naturally influenced by altitude as much as location. Unfortunately, in most cases available data has not so far permitted an assessment of rainfall expectations by month. It has nonetheless been possible to derive **indicative** annual expectations for each of the sub-basins.

It is important to remember however, that mean rainfall figures can mask wide but normal, temporal, that is to say monthly or inter-annual variations and long term trends that may or may not be due to climate change.

To the greatest extent possible with the time and information resources available to the consultants Figure 7.1 is an attempt to describe these variations. It should be studied in consultation with Figure 7.2. It will seen that the nature and scope of the commentaries is highly variable. This is due to the variable quality and extent of the source data and information, which unless otherwise stated has been taken from the country baseline documents. It should also be noted that there are inconsistencies between the various sources of data., these have been mitigated in the table to the greatest extent possible.

Figure 7.1 Rainy Season Variation With Lattitude

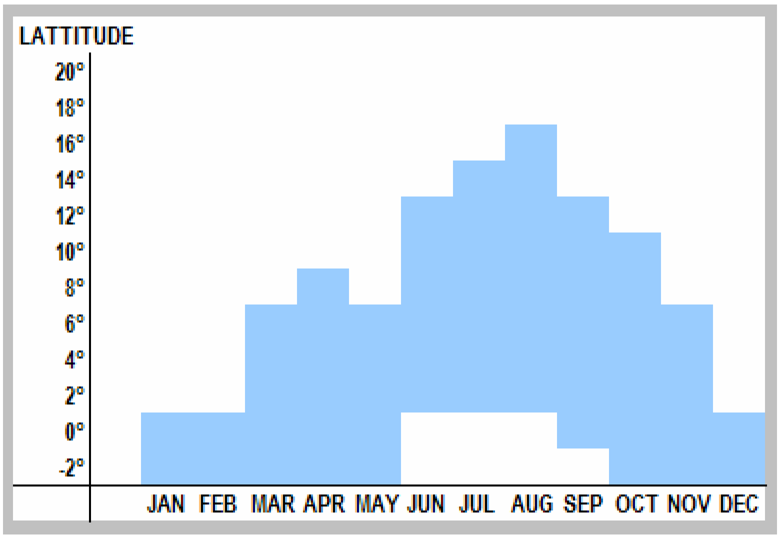
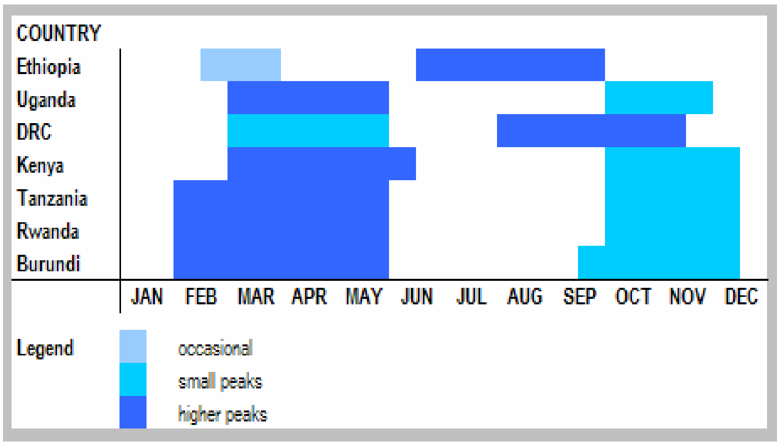


Figure 7.2 Seasonal Rainfall Peaks



7.1.3 Temperature and Evaporation

As with rainfall, temperature and evaporation also vary widely across the NB, ranging from cold conditions in the desert winter nights where temperatures fall as low as 4°C and mountainous areas where even freezing conditions are encountered to searing heat, often exceeding 40°C, again in the desert regions. In some areas, especially in parts of the Equatoral Lakes Regions, temperatues vary little from month to month, while yet again in the desert regions, they vary widely throughout the year.

Table 7.2 follows the same pattern as Table 7.1. but deals with temperature and where data is available it also presents evaporation data.

Table 7.1 Mean Rainfall Expectations in the Sub-Basin

SUB-BASIN	COUNTRY(IES)	RANGE (mm)		COMMENTARY
		FROM	TO	
Kagera	Burundi	750	1200	Rainfall arises due to convection, orographic and frontal reasons. The low figure provided here concerns the extreme NE of the country, and the higher figure applies to the central plateau which comprises the major portion of the country's share of the NB. Interannual variability is moderate with, in national terms, a 1 in 10 dry year precipitation corresponding to 83% of mean annual preciptation. This happy situation however, is reportedly being compromised over the longer term by drought conditions that have been increasing over the past 10 years. These figures could be compared with 895mm and 1570mm and a long term mean of 1110mm suggested in FAO 1997
	Rwanda	700	2000	Rainfall in Rwanda is a function of the Inter-Tropical Convergence Zone which produces heavy rainfall March-May and October-December. In general terms, mean annual rainfall expectation increases from east to west as per the figures given in this row. However, in the higher areas, these figures increase to around 1600mm and above.
		700	1100	• in the east
		1000	1300	• on the central plateau
		1300	2000	• in the high altitude regions As with Burundi, a long term drought trend is emerging, particularly in the east and south-west.
				These figures could be compared with 840mm and 1935mm and a long term mean of 1105mm suggested in FAO 1997
	Tanzania	900	1900	These are the mean annual expectations, although long term record indicate a slightly rising trend. The lower figure applies to the extreme south and west of Tanzania's share of this sub-basin, while the higher figure concerns the extreme north east, on the shore of Lake Victoria. Inter-annual variations are of around plus or minus 30% are common and possibly increasing
Lake Victoria	Tanzania	700	1400	These are the mean annual expectations rising from the extreme south to the north. Interannual variation of around plus or minus 50% have been common, but seem to be decreasing. The figures for Tanzania (for both the Kagera and Lake Victoria sub-basins) are generally consistent with FAO 1997: 625mm, 1630mm and 1015 for minimum, maximum and long term means respectively.

SUB-BASIN	COUNTRY(IES)	RANGE (mm)		COMMENTARY
		FROM	TO	
	Kenya	1000	2000	These are the mean annual expectations in the north, south-west and lake shore lowlands (low figure) and the highlands (high figure). They could be compared with FAO 1997: 505mm, 1790mm and 1260mm for minimum, maximum and long term means respectively.
	Uganda	395	2060	According to FAO 1997, this is the inter-annual variation of mean annual rainfall. The long term mean is around 1180mm. It should be noted however, that this figure applies to the country as a whole, there being no data available specific to this sub-basin.
Victoria Nile	Uganda	860	1315	In the absence of other data, these figures have been estimated from bar charts contained in FAO's "Kyoga-Poster" FAO 2006 under the programme "Information Products for Decisions on Water Policy and Water Resources Management in the Nile Basin". The lower figure applies to Moroto and the higher to Soroti, both of which lie in the Kyoga sub-catchment (which drains to the Victoria Nile). They are consistent with the broader range quoted for the whole country by Encarta (900mm in the north to 1500mm in the south). Local variations however, tend to be large.
Semliki – Lake Albert	DRC	875	1915	According to FAO 1997, this is the inter-annual variation of mean annual rainfall. The long term mean is around 1214mm.
	Uganda	395	2060	FAO 1997, comments as above.
Albert Nile – Bahr el Jabal	Uganda	395	2060	FAO 1997, comments as above.
	Sudan	1000	1500	This is the range of mean annual rainfall suggested in ENTRO 2000b. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.
Bahr el Ghazal	Sudan	800	1300	This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the south western portion of the sub-basin and the lower to the northern.
Sudd	Sudan	800		This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.
Sobat	Ethiopia	680	3000	This the spatial range of annual mean expectation, the lower figure refers to the lowland area, the higher to the highlands.
	Sudan	700	1500	This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.

SUB-BASIN	COUNTRY(IES)	RANGE (mm)		COMMENTARY
		FROM	TO	
Lower White Nile	Sudan	200	1000	This is the range of mean annual rainfall suggested in ENTRO 2006. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.
Blue Nile	Ethiopia	680	2800	This the spatial range of annual mean expectation, the lower figure refers to the lowland area, the higher to the highlands.
	Sudan	200	1300	This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the south eastern portion of the sub-basin and the lower to the north western.
Main Nile 4	Sudan	50	200	This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.
Atbara	Ethiopia	800	2000	This the spatial range of annual mean expectation, the lower figure refers to the lowland area, the higher to the highlands.
	Eritrea	240	665	According to FAO 1997, this is the inter-annual variation of mean annual rainfall. The long term mean is around 520mm.
	Sudan	50	1100	This is the range of mean annual rainfall suggested in ENTRO 2006. The higher figure refers to the south eastern portion of the sub-basin and the lower to the north western.
Main Nile 3	Sudan	<20	50	This is the range of mean annual rainfall suggested in ENTRO 2006b. The higher figure refers to the southern portion of the sub-basin and the lower to the northern.
	Egypt	0	5	This is the temporal range of annual expectation.
Main Nile 2	Egypt	0	5	This is the temporal range of annual expectation.
Main Nile 1	Egypt	100	225	This is the temporal range of annual expectation.

Table 7.2 Mean Temperature and/or Evaporation Expectations in the Sub-Basin

SUB-BASIN	COUNTRY(IES)	RANGE		COMMENTARY
		FROM	TO	
Kagera	Burundi	16°	20°	This is the inter-annual range of mean temperatures on the central plateau. Potential evapotranspiration over the entire country is given as 842 mm.
	Rwanda	16°	17°	This is the mean annual variation in the high altitude region, although frost conditions can occur at night in the NW mountains (Encarta)
		18°	21°	This is the mean annual variation in the central plateau

SUB-BASIN	COUNTRY(IES)	RANGE		COMMENTARY
		FROM	TO	
		20°	24°	This is the mean annual variation in the lowlands of the east and west. Thus it can be concluded that monthly variations in mean temperatures are small, and this would seem to be true also of inter-annual fluctuations, although highs of up to 35° have been reported.
	Tanzania	1150mm	1270mm	These are the mean annual evaporation rates. No temperature data has been available so far
Lake Victoria	Tanzania	1800mm	1900mm	ditto
	Kenya	15°	25°	This is the variation in mean monthly temperatures throughout a typical year, daily temperatures vary more widely however, from 15° to 30°.
	Uganda	18°	28°	Long term range for January according to Encarta
		17°	25°	Ditto July
Victoria Nile	Uganda	1470mm	1680mm	Potential evapotranspiration at Moroto and Namulonge respectively – both of which lie in the Kyoga sub-catchment.
Semliki – Lake Albert	DRC	23°	15°	As is usual, temperature varies inversely with altitude, the lower figure is the mean annual temperature at 1000m and the higher, at 2000m
	Uganda	not known		
Albert Nile – Bahr el Jabal	Uganda	not known		
	Sudan	29°		Mean daily temperature for the south of Sudan as suggested in the ENTRO 2006c
Bahr el Ghazal	Sudan	29°		dtto
Sudd	Sudan	29°		ditto
Sobat	Ethiopia	16.5°	27°	Temperature range suggested in ENTRO 2006d “Data Collection and Compilation on Environment and Related Issues in Eastern Nile Sub-basin in Ethiopia” ENTRO 2006d. The lower value concerns altitudes above 2500 masl and the upper, altitudes below 500 masl. The same source also adds the following details:
		24°	35°	• range of mean maximums
		10°	20°	• range of mean mimmums
		1050mm	1100mm	Annual range of evaporation rates for the highest elevations
		1801mm	1900mm	Annrange of evaporation rates for the lowest elevations

SUB-BASIN	COUNTRY(IES)	RANGE		COMMENTARY
		FROM	TO	
	Sudan	15°	25°	This range of mean annual temperatures is suggested by the "Sudan Cooperative Regional Assessment for Watershed Management - Transboundary Analysis Final Country Report – Sudan" ENTRO 2006e for scattered portions in the very south of the sub-basin
		25°	17°	This range of mean annual temperatures is suggested by ENTRO 2006b as applicable to the greater part of the sub-basin with minor exceptions as identified thus:
		27°	28°	• in the centre, north and scattered portions in the very west
		23°	25°	• in scattered portions of the very western tip of the sub-basin
		1901mm	2150mm	This range of mean annual evaporation is suggested by ENTRO 2006b for a small area at the southern boundary of the sub-basin
		1451mm	165mm	This range of mean annual evaporation is suggested by ENTRO 2006b for a small scattered areas in the south of the sub-basin
		1651mm	1900mm	This range of mean annual evaporation is suggested by ENTRO 2006b for most of the southern half of the sub-basin
		2151mm	2500mm	This range of mean annual evaporation is suggested by ENTRO 2006b for the northerly 25% of the sub-basin.
		1901mm	2150mm	This range of mean annual evaporation is suggested by ENTRO 2006b for a small area at the southern boundary of the sub-basin
Lower White Nile	Sudan	12°	25°	This range of monthly mean temperatures is suggested by ENTRO 2006b Draft. The lower figure refers to January and the higher to July.
Blue Nile	Ethiopia	6°	10°	Mean annual temperature range at the highest elevations
		25°	28°	Mean annual temperature range at the lowest elevations
	Sudan	25°	26°	This range of mean annual temperatures is suggested by ENTRO 2006b for the southern margin of the sub-basin
		26°	27°	This range of mean annual temperatures is suggested by ENTRO 2006 for the south westerly third of the sub-basin
		27°	28°	This range of mean annual temperatures is suggested by ENTRO 2006b for the north easterly two thirds of the sub-basin
		26°	27°	This range of mean annual temperatures is suggested by ENTRO 2006b for the north eastern margin of the sub-basin

SUB-BASIN	COUNTRY(IES)	RANGE		COMMENTARY
		FROM	TO	
		1750mm	1900mm	This range of mean annual evaporation is suggested by ENTRO 2006b for the south eastern tip of the sub-basin
		1901mm	2050mm	This range of mean annual evaporation is suggested by ENTRO 2006b for the portion of the sub-basin situated south of lattitude 12°N
		2051mm	2250mm	This range of mean annual evaporation is suggested by ENTRO 2006b for the portion of the sub-basin situated between lattitude 12°N and a line running from 13°24' N, 33°30' E and 15°N, 35E.
		2251mm	2450mm	This range of mean annual evaporation is suggested by ENTRO 2006b for the remainder of the sub-basin.
Main Nile 4	Sudan	27°	28°	This range of mean annual temperatures is suggested by ENTRO 2006b.
Atbara	Ethiopia	10°	26°	Temperature range suggested in ENTRO 2006d for the Simien Highlands and below 600 masl respectively The same source also adds the following details:
	Eritrea	22°		• mean temperatures for the majority of the sub-basin
	Sudan	28°	29°	This range of mean annual temperatures is suggested by ENTRO 2006b, as applicable to the north western portion of the sub-basin
		27°	28°	This range of mean annual temperatures is suggested by ENTRO 2006b, as applicable to the most of the sun-basin
		26°	27°	This range of mean annual temperatures is suggested by ENTRO 2006b, as applicable to a thin strip at the very eastern margin of the sub-basin
Main Nile 3	Sudan	24°	26°	This range of mean annual temperatures is suggested by ENTRO 2006b, as applicable to the southern portion of the sub-basin
		27°	28°	Ditto the central portion of the sub-basin
		22°	24°	Ditto the northern portion of the sub-basin
	Egypt	9°	>40°	Night and day temperatures at Aswan
			2400mm	Mean annual potential evapotranspiration rate
Main Nile 2	Egypt	7°	43°	Night and daytime temperatures in summer
		0°	18°	Night and daytime temperatures in winter
		2000mm	1800mm	Mean annual potential evapotranspiration rate in the south and north of the sub-basin respectively
Main Nile 1	Egypt	14°	30°	Mean winter and summer temperatures respectively

SUB-BASIN	COUNTRY(IES)	RANGE		COMMENTARY
		FROM	TO	
		1800mm	1700mm	Mean annual potential evapotranspiration rate in the south and north of the sub-basin respectively

7.2 Surface Flows Between Sub-basins

As mentioned at the beginning of section 1.1, the principles of Integrated Water Resources Management, require that water management and allocation decisions are made at the basin or sub-basin level to the greatest extent.

The graphic presented to the right (Figure 2.1) summarises the sub-basin delineations proposed in Section 1.1 and thereby provides a simple illustration of the order by which flows accrue to the main streams of the Nile.

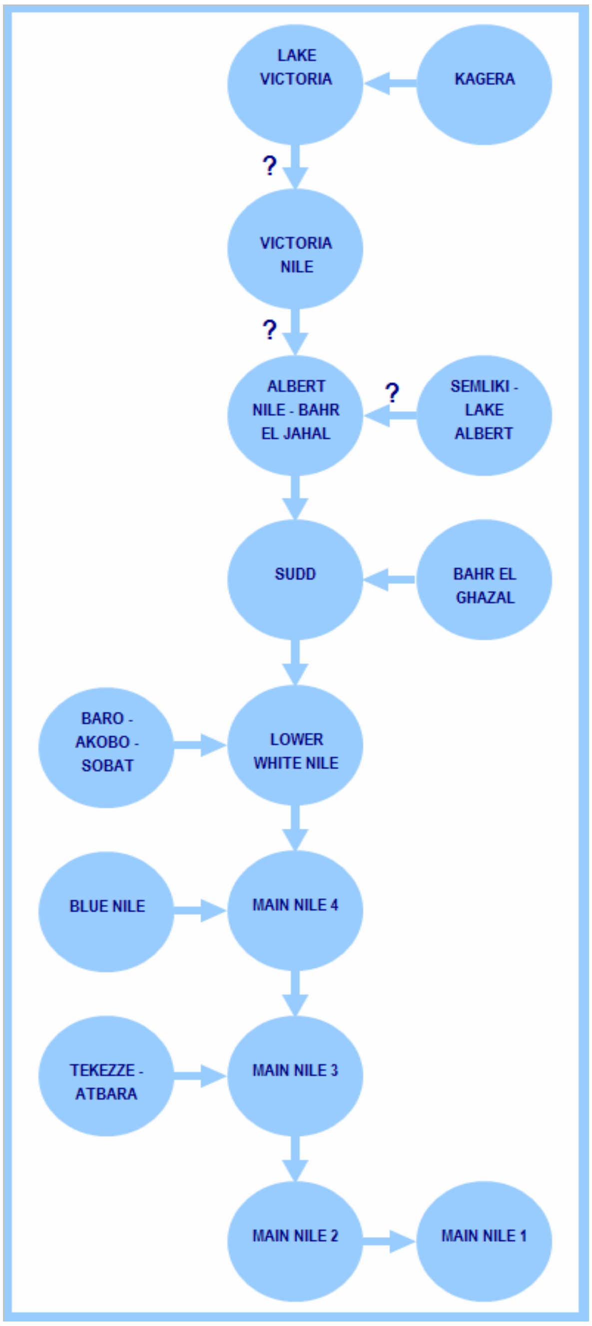
A considerable amount of effort has been expended by the consultants while trying to agglomerate water availability data according to this scheme. Unfortunately this did not prove possible for all of the sub-basins from the data/information and time available during the Inception Phase. As a result the flows indicated by the question marks could not be estimated. Equally, not all of the source data was available as monthly means - only long term annual means being available in some cases. However, further efforts will be made to fill these gaps during the remainder of the study.

Nonetheless, using such data that was available, it was possible to prepare Table 7.3 which provides an indication of the annual mean flows from one sub-basin to another.

As with rainfall and other climatic parameters, flows in most of the sub-catchments exhibit seasonal variations. For sub-basins for which data is available these are shown as monthly flows in Figure 7.4, and as percentages of annual flows in Figure 7.5. Both figures show that sub-basin flows in the Nile Equatorial Lakes region tend to peak between April and May, while the Blue Nile and Atbara peak in August and Sobat in November.

A similar analysis of the main Nile north of Aswan High Dam would be meaningless

Figure 7.3 Sub-basin Linkages



however as the flows are subject to the operating rules of the dam, and by return flows which increase in the downstream direction.

Table 7.3 Flow in Billion m3 Entering the Reach from the Sub-basins/Side-streams

SUB-BASINS or side-streams	RIVER REACH: Lake Victoria	Victoria Nile	Albert Nile - Bahr el Jahal	Sudd	Lower White Nile	Main Nile 4	Main Nile 3	Main Nile 2	Main Nile 1
KAGERA	0.345								
from Tanzania	0.245								
from Kenya	0.304								
from Uganda	0.000								
nett rainfall onto Lake Victoria	unknown								
LAKE VICTORIA		0.895							
from Uganda		unknown							
VICTORIA NILE			0.895						
SEMLIKI - LAKE ALBERT			unknown						
from Uganda			unknown						
ALBERT NILE - BAHR EL JAHAL				33.332					
BAHR EL GHAZAL				0.500					
SUDD					16.091				
SOBAT					13.530				
LOWER WHITE NILE						26.000			
BLUE NILE						48.279			
MAIN NILE 4							72.691		
ATBARA							11.050		
MAIN NILE 3								84.180	
MAIN NILE 2									40.00

Legend

0.345	signifies inflow from sub-basins or u/s reaches
0.245	signifies pick-up flows from tributaries

Figure 7.4 Mean Monthly Flows of selected Rivers/Catchments

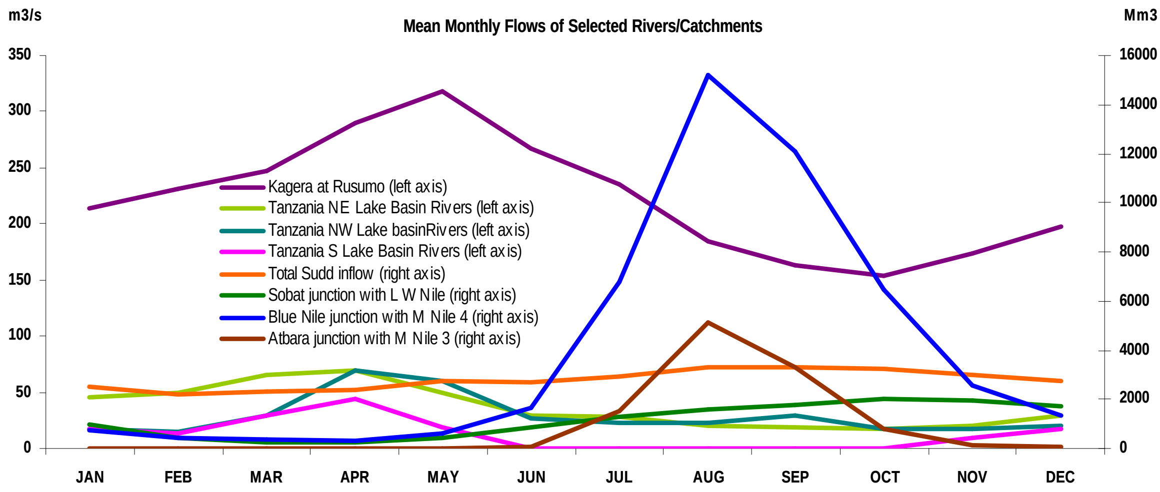
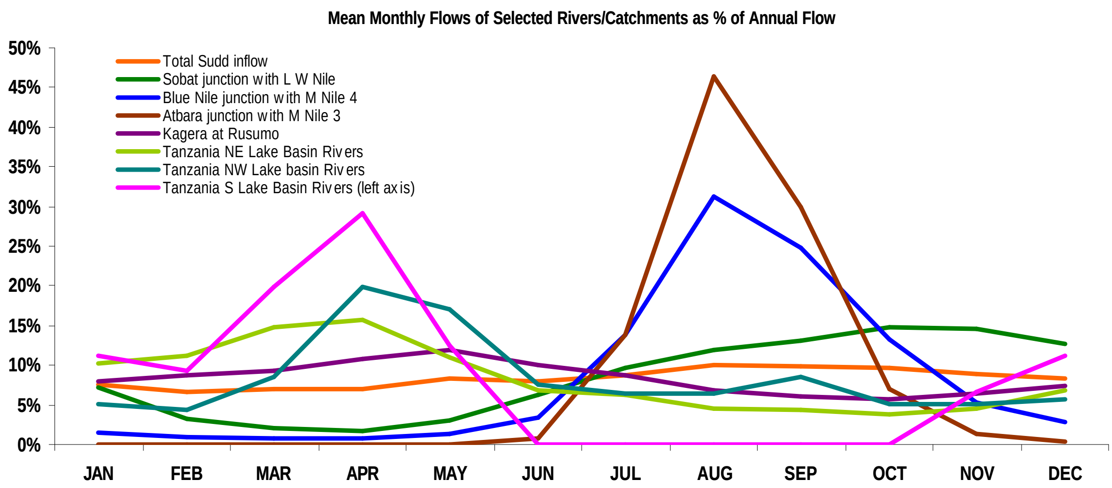


Figure 7.5 Mean Monthly Flows of selected Rivers/Catchments



7.3 Groundwater

Despite significant unexploited groundwater resources in the NB, it already plays a significant role in the socio-economy and productivity of the basin. In Burundi for instance, the country baseline report tells us that it is “extensively exploited” there. And all over the basin for instance it is a common source of water for both rural and urban water supply and sanitation. This is especially so for people that are not connected to formal delivery systems. In the Sudan for instance, some 80% of the population relies on groundwater for its domestic water (“Data and Information on Environment and Related Issues in Eastern Nile Sub-basin in Sudan” ENRO 2006).

It also has potential for irrigation, either exclusively or in conjunctive use with surface water. Behailu 2006 mentions for example that Ethiopia has an estimated 2.6 billion m^3 of groundwater and cites proposals for its development for conjunctive use, especially where recharge from irrigation is likely to be significant. Similarly Egypt has developed proposals for greater use of groundwater to supplement ist surface water for irrigation purposes.

Another under exploited application is cattle watering. In Peden, Freeman, Astatke and Notenbaert, 2005 write that “appeals from the government of Sudan emphasise the need to develop strategically placed groundwater based watering facilities that can enable pastoralists to take advantage of large rangeland areas that are currently unsuitable because of a lack of drinking water for animals”.

Groundwater utilisation also represents significant potential for drought mitigation.

Yet there is a risk of over-exploitation, and inter-sectoral competition, especially between agriculture and water supply and sanitation, for it is already encountered in the basin. In this context, a study quoted by the Cooperative Regional Assessment (CRA 2007a) recommends that for South Kassala (Sudan) groundwater should be reserved for domestic supplies leaving agriculture dependent on surface water.

Given all this, an extensive knowledge base concerning the extent and sustainable yields of the basin’s groundwater is clearly desirable. However, with some notable exceptions, knowledge remains limited, a problem which is repeatedly highlighted in the literature, not least the country reports.

With this in mind it is also important to note that groundwater existence and availability are two different things and defined by the transmissivity of the aquifers themselves. In the Atbara sub-basin for instance, it is reported (CRA 2006a) i) that the Nubian aquifers contain some 840 million m^3 of which only 8.4 million m^3, or 1% are sustainably exploitable and ii) that in more other aquifers, the so-called Neogene-Recent deposits, the total resource is only 222 million m^3 of which 11.2 million m^3 or 5% are sustainably exploitable.

Low groundwater potential is also associated with the Blue Nile sub-basin, and in Uganda, where the country baseline report states that groundwater is limited in both quantity and extent. In neighbouring Rwanda however, its baseline report mentions that groundwater supplies 66 m^3/s to surface water resources of which 57 m^3/s contributes to river baseflows (2.1 km^3/yr and 1.8 km^3/yr respectively).

Several recharge mechanisms are encountered in the baseline. The most obvious is natural recharge accruing to wetlands, precipitation and natural drainage. This is reportedly becoming increasingly compromised as a result of wetland drainage (see section 7.7) and changing land cover/use and is manifested by reducing baseflows in the surface streams. Even so, the document “Transboundary Analysis – Main Nile Sub-basin” mentions that farmers in the Sudan are able to exploit groundwater for irrigation purposes as far as 15 km from the river itself!

Recharge also results from storing water behind dams. FAO’s AQUASTAT estimates for instance that the seepage under the Aswan High Dam totals around 1 km^3 annually. Unlined, or partially lined canals also contribute to recharge, sometimes significantly so. Thus AQUASTAT also estimates that some 6 km^3/yr accrues to deep percolation from the extensive canal system along the Nile Valley.

In addition to competition and limited knowledge concerning the NB’s groundwater resources, other reported problems include pollution due to the deep percolation of agricultural chemicals and human waste and saline intrusion at the coastal margins of the Main Nile 1 sub-basin. This is apparently due to over abstraction of the available groundwater, which is particularly interesting given Egypt’s plans to increase its equipped irrigated area on the basis of mined, fossil groundwater. However, since by definition fossil water is not recharged, by Nile or any other water, it has no implications for this study.

8 Specific Thematic Issues

8.1 Water scarcity/droughts, flood protection, disaster preparedness and management

8.1.1 Water Scarcity and Droughts

For the purpose of this section water scarcity is defined as ***inadequacy in comparison to demand***, while drought is defined as a ***negative, climatic aberration away from expected conditions***. It is important to make this distinction as scarcity can be mitigated proactively by catchment protection, demand management, storage (trans-seasonal or trans-annual),and strategic water allocation – all of which will be facilitated by the DSS; and by the improved management of withdrawals and maximised return flows. By way of contrast and notwithstanding anthropomorphic climate change, drought is something that is beyond human control, although they can be mitigated both on a prophylactic basis by the provision of storage facilities for instance or reactively, ideally on the basis of pre-existing response plans.

A helpful overall indicator of water scarcity, which has both spatial and temporal characteristics, is the length of growing season at a particular location; Figure 8.11 refers. This figure, which does not differentiate between irrigated and rainfed growing seasons, clearly suggests a prevailing lack of scarcity in the far South, with scarcity increasing rapidly with latitude such that most of the Eastern Nile Region is completely water scarce with the exception of the Egyptian Nile where scarcity is in any case mitigated by the Aswan dams. As mentioned above however, given adequate economic resources, scarcity can be mitigated by investments in water management infrastructure.

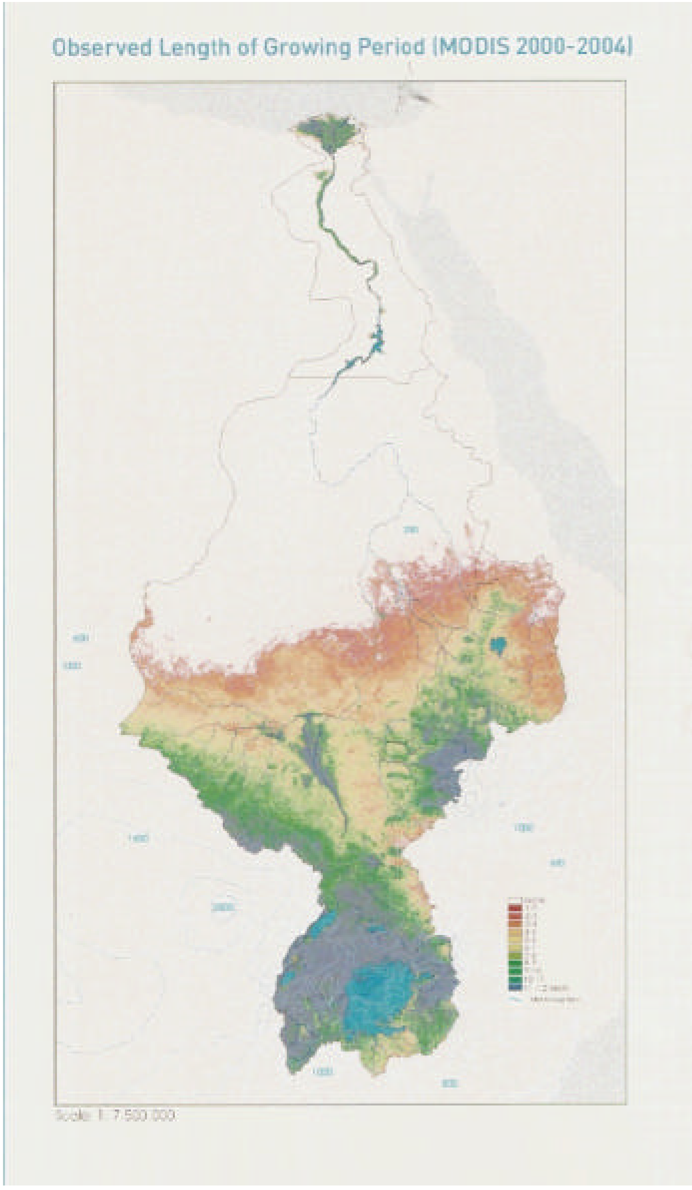
It is interesting to note therefore, that the International Water Management Institute (IWMI) describes two kinds of water scarcity (Molden, Amarasinghe and Hussain 2001):

- Physical Water Scarcity: which is defined in terms of the magnitude of primary water supply (PWS) development with respect to potentially utilizable water resources (PUWR). The physical water scarce condition is reached if primary water supply of a country exceeds 60% of its PUWR. This means that even with the highest feasible efficiency and productivity, the PUWR of a country is not sufficient to meet the demand of agriculture, domestic and industrial sectors while satisfying its environmental needs. Countries in this category will have to transfer water from agriculture to other sectors and import food or invest in costly desalinization plants.
- Economic Water Scarcity: economically water-scarce countries have sufficient water resources to meet their additional PWS needs, but they require increasing their PWS through additional storage and conveyance facilities by more than 25%. Most of these countries face severe problems related to both financial and institutional capacity for development for increasing PWS to those levels.

Against these definitions, IWMI estimates that although only Egypt faces physical water scarcity in the short to medium future (ie to 2025) **all** the other riparian countries face or will face economic scarcity.

The economies of the NB riparians are dominated by agriculture, in terms of both GDP and livelihoods. In such countries, if irrigation i) is a dominant user of water and ii) is necessary to mitigate the seasonality and variability of rainfall, another useful indicator of scarcity (or a lack thereof) is therefore the extent of undeveloped irrigation potential. In other words, if the agricultural sector is a major user of water (usually for irrigation) and if irrigation is significantly underdeveloped than scarcity is low, and vice-versa (The Republic of South Africa for instance which has already developed some 98% of its irrigation potential is classified by IWMI as physically water scarce). FAO has compared undeveloped irrigation potential in the Nile Basin with available water resources (FAO 1997 and FAO 2005) – the following table refers:

Figure 8.1 **Length of Growing Season in the Nile Basin**



Source: FAO,2006

Table 8.1 **Irrigation in Nile Basin**

	IRRIGATION/AGRICULTURE			
COUNTRY	use as % of total abstractions	potential within NB (ha)	area already irrigated in NB (ha)	% of potential
Burundi	77%	80,000	not known	not known
Rwanda	68%	150,000	2,000	1%
Tanzania	89%	30,000	10,000	33%
Kenya	79%	180,000	6,000	3%
DRC	31%	10,000	0	0%
Uganda	40%	202,000	9,120	5%
Ethiopia	94%	2,220,000	23,160	1%
Eritrea	95%	150,000	15,124	10%
Sudan/1	97%	2,750,000	1,380,000	50%%
Egypt	86%	4,420,000	3,078,000	70%

[1] FAO 1997, with updated information from Sudanese comments on Draft IR

Notes

1 not including the Sudd swamps

2 despite high development of its irrigation potential, Sudan is not physically water scarce because use of PUWR does not exceed 60%

Based on the foregoing, it is reasonable to conclude therefore that given adequate economic resources, and sound technical approaches to demand management and to the allocation and management of water in the Nile basin, that with the exception of Egypt, physical water scarcity is not an issue – at least not at the basin level or national levels. This does not mean however, that as one approaches the point of use that localised scarcity is not an issue – but this is beyond the scope of the DSS and hence of this document.

Even where water would seem to be plentiful in relation to the demands upon, drought events compromise the availability of water and are widely reported throughout the basin where records of droughts go back to biblical times. They are known to result from non-controversial phenomena such as El Niño and possibility others. Such influences explain normal long term drought events. But such events have begun to increase in intensity and frequency throughout the basis where their effects are worsened by population growth and catchment degradation. Increases in intensity and frequency are thought to arise from atmospheric pollution, global warming and associated climate change and are manifested either by increasingly unmanageable rainfall events or by increasing variability in rainfall.

In Uganda for instance, changes in climate are causing extreme weather events leading to disasters in the form of droughts and floods (see below), and the frequency of extreme events has increased in recent years. Since 1997, Uganda has endured two El Nino related drought cycles and between the 30-year period from 1970 - 2000 there have been twice as many droughts as there were in the 50-year period from 1920 to 1970. In addition, droughts can be seasonal or long term and the country recently suffered from a prolonged drought that has caused water shortages across the country leading even to water level drops in various water sources, including Lake Victoria. This situation changed dramatically in recent days[1] when some 400,000 people were affected by the catastrophic floods covering a band running east-west from Ethiopia to Senegal (again, see below).

1 Mid-September 2007

Similarly Rwanda is increasingly experiencing long periods of drought which tend to become cyclical and persistent, particularly in the East and South West, while in Burundi, decreasing spring flows are through to result from ongoing changes in rainfall expectation.

Despite these cases in the Nile Equatorial Region droughts are reportedly more likely and more severe in the Eastern Nile region which is characterized by highly variable climate and river flows, making it prone to consequences of extremes of droughts and floods even in areas such as the Ethiopian and Eritrean highlands where “normal” rainfall is associated with long growing seasons and usually high biomass. Although the degrees of the effects of drought have always varied from year to year (drought has been a recorded phenomenon in Ethiopia since 250 BC) the past three decades have seen recurrent droughts to become more severe and affect the lives of millions of Ethiopians every year.

Despite the increased risks associated with the Eastern Nile countries, throughout the NB as a whole, drought is often claimed to be most significant livelihood threat to the rural poor who can be caught up in vicious spirals whereby their response to a given drought both increases the effects of the next one while reducing their ability to mitigate their effects. This is because catchment deterioration caused by deforestation (as a drought response – people affected by drought in one location are known to open up new, virgin locations) reduces the ability of the natural system to attenuate rainfall events and thereby mitigate drought.

8.1.2 Flood Protection

Due to the seasonality of rainfall in the Nile Basin, flooding is an essential feature of the Basin’s hydrology and has characterised its exploitation and indeed the culture of those benefiting since time immemorial. However, as indicated above, floods are also a threat in the Nile basin and have become increasingly so. and in fact when caused by high intensity rainfall (rather than saturated watersheds) are also associated with drought. There are two approaches for dealing with floods, one is to protect live, livelihoods and property from them, the other is to mitigate their effects. This sub-section is concerned only with the former, mitigation is addressed as a disaster preparedness and management issue in the next.

Despite the apparent increase in frequency and severity of flooding in the Nile basin, the literature suggests a pressing inadequacy of protection infrastructure. In Kenya for instance, the National Policy on Irrigation and Drainage (June 2007) for instance refers to substantial agricultural land that „is un-useable due to seasonal flooding. This is due to lack of flood protection measures....“; while with specific reference to the NB the country baseline report mentions several flood protection projects (proposed and actual) which provide dykes for the purpose of containing riverine flood peaks. However, in the absence of attenuating storage downstream (either in the form of natural wetlands or man made dams), the provision of dykes merely shifts the problem downstream.

Flood peak attenuation has long been practised in Egypt however. The El Kafara Dam for instance, was constructed in the period 2700-2600 BC as a flood protection measure for the lower Wadi Garawi and the Nile Vallley in front of the Wadi, where there were agriculture and other settlements. More recently, the Aswan High Dam was constructed as a flood management as well as storage measure. But even that, it is noted, has had its operating rules changed as a result of increased incoming floods (Annex B-2 of the DSS Baseline Report refers).

Similarly, the Koka Dam, built on the Awash River in Ethiopia during the late 1950s had a flood protection as well as storage objective. Dykes have also been used for flood protection in Ethiopia, for instance at the 10,000 ha Amibara Irrigation Scheme. Ethiopia is also interesting because it provides a good example of a combined institutional, operation and investment approach to flood protection. The River Training Unit for the Lower Plains area is responsible for maintaining river cross sections in order to avoid any constraints on the passage of floods, and to construct flood protection dykes to protect farmers along the river banks (Achamyeleh).

Despite these few examples, flood protection remains inadequate through much of the Nile Basin, hence the devastating floods that affect Uganda, Kenya, Ethiopia and Sudan at the time of writing[2]. As result of these floods, 250,000 people have been rendered homeless in Sudan alone, with official expectations that the situation will worsen! 4000 people are stranded in Afar, Ethiopia.

As well as inadequate flood protection facilities, problems are also reported with respect to decreased natural attenuation due, usually, to wetland encroachment and development as well with poor land management in the highland areas. In Ethiopia for instance, according to CRA 2007b "many of the Dinder-Rahad wetlands are now cut-off from the main river systems by the expansion of large-scale rainfed agriculture. It is not known how far this is responsible for the recent flooding and far they are due to silting up of small lakes and ponds from sediment derived from the Ethiopian highlands......With the accelerated erosion in the Ethiopian Highlands this gradual and long term evolutionary process has been disturbed because increased flood peaks and high sediment loads. The area is now subject to annual flooding".

8.1.3 Disaster Preparedness and Management

Disasters relevant to this study largely comprise drought; floods and infrastructural failure. With respect to the latter it is interesting to note that as a result of the current floods, some 4000 people have been stranded, homeless as a result of the failure of a dam in Afar. Although Afar is not in the NB, the incidence confirms the reality of the threat.

Disaster preparedness comprises a combination of early warning systems, prediction models and responsive institutions while management involves mitigation measures, institutions (once again) and procedures.

The availability and sophistication of such preparedness and management measures various throughout the basin; but the measure most commonly prioritised among the riparians is famine forecasting for which assistance has been forthcoming from several sources such as FAO or USAID. However, the causes of famine are not limited to water shortages. Pest, disease and stong winds are also possible causes. Accordingly, as far as famine forecasting is concerned this text is limited only to the drought element.

Probably the most signficant drought forecasting facility within the basin would be the Kenyan Drought Monitoring Centre which was established in 1989 and charged with predicting and mitigating the adverse impacts of extreme climatic events on water resources, agricultural production and food security etc. The Centre is particularly relevant here because it reportedly serves several regional countries including seven riparian countries: Burundi, Ethiopia, Eritrea, Rwanda, Sudan Tanzania (which has its own Disaster Management Department) and Uganda. In addition, its operational activites include the timely disemination of early warning products throughout the region.

Kenya also has a meteorological department (within the Ministry of Transport and Communication). The Department is responsible *inter-ali*a, for flood and drought forecasting and at the time of writing has been collaborating with the Office of the President in setting up a flood warning system for the Nzoia river, financed by the World Bank and implemented under community based modalities.

2 Africa flood zones face more rain: http://news.bbc.co.uk/2/hi/africa/7002640.stm 19 September 2007

Similarly, Ethiopia has a national disaster prevention and preparedness commission – however, the available literature is not clear on its mandate. Equally, Uganda has a very interesting disaster preparedness and management policy. Although it is not specific with respect to what kind of disaster it is supposed to deal with, it promulgates an integrated, mult-sector approach while calling for a comprehensive and effective early warning system.

There are also regional initiatives in progress. The Eastern Nile Watershed Management CRA for instance, has developed a substantial GIS that, in addition to being of considerable (potential) relevance to the Eastern Nile Planning Model, is intended to provide inputs to the Irrigaton and Flood preparedness CRA.

The ENSAP/IDEN also has a flood preparedness aand early warning system as one of its seven proposed components.

Prediction models are also available, although it would appear that some are more widely used than other. Egypt for instance has and Unsteady State Hydraulic Model (called Sobek after the ancient god of the river). In a typical application, the programme is used to simulate the progression of floodwater and teh depth of flooding along a river or canal system. Inter-alia, it can be applied to flood prediction (including risk and damage assessment), dam break analysis and disaster management.

Kenya also has relevant models. The GeoSFM run-off model for instance has been applied to the Nyando and Mara basin. Along with other models (WAM and SWAT) it has been calibrated and validated for the Lake Basin catchments. Despite this however, these models have been focussed more on research than forecasting, although the GeoSFM model is reportedly intended to be used for flood forecasting in theNzoia basin.

8.2 Soil salinization / drainage

There are several reasons why drainage is needed and indeed practised to some extent, in the NB. It is used:

- to control flooding
- to reduce waterlogging
- to control or reduce salinity and sodicity
- to control saline intrusion (at the coastal margins of the Main Nile 1 sub-basin)
- for the reclamation of wetlands, and to facilitate valley bottom irrigation as for instance in the Baro-Akobo valley and in Kenya's Kisii district
- to allow the re-use of irrigation return flows, although as will be seen below, in the absence of a suitable regulatory framework such re-use introduces the danger of increased salinisation

Despite unquestionable successes, drainage remains problemmatic in the NB, and the identified problems result not only from a lack of adequate drainage across much of the NB, but also because drainage facilities are underperforming, deteriorating, silting up or not well used and even because in some places there is too much.

Typical problems include:

- Flooding
- excessive drainage of wetlands is blamed not only for compromising vital wetland functions (including groundwater recharge) but also for agricultural production on the reclaimed lane that is less than potential (CRA 2007a).
- Drainage channels can be badly choked with water hyacinth (Elzein 2007)

- constrained agricultural production is widely related to poor drainage in the literature, due both waterlogging and salinity/sodicity problems

Problems of salinity, which is cited as one of the three biggest problems in rural agriculture (the others being malaria and weeds - "Environmental Assessment of Eastern Nile Sub-basin" ENTRO 2007 refers) are doubly troublesome because not only do they reduce agricultural productivity they are also caused by poor agricultural practices, including soil and water management.

Equally, in some isolated cases salinity reduction, caused by excessive agricultural run-off is resulting in lost fish biodiversity in certain brackish lakes at the north of the Main Nile 1 sub-basin.

Proposals for improving, extending or rehabilitating drainage facilities as well as for introducing alternative uses for drainage feature in many country reports and other NBI literature; even so as will be shown below, for the most part, inadequate drainage and the related problems of salinity and sodicity is mainly an issue in Eastern Nile Basin and only of minor concern in the Equatorial Lakes Region.

According to the Burundi baseline report for instance, salinity only occurs in marshes where it rises and falls as a natural annual cycle. Similarly no drainage related soil problems are reported for Rwanda or the DRC. For Tanzania however, FAO's AQUASTAT mentions tat some 50,000 ha have a drainge related salinity problem, but it is not clear whether any of this is situated in the NB.

Kenya's new Irrigation and Drainage Policy refers to an area of 600,000ha which requires drainage, of which only 30,000 is currently drained and and of this some of this requires rehabilitation. By way of comparison FAO's AQUASTAT mentions 30000ha of salinated soils due to poor drainage - but confirms that this is in the centre of the country, and not in the NB. It can therefore be assumed that drained areas such as those known to exist in Kisii District (which is the NB) present no problems.

Uganda has only 3,000 ha of drained land, yet the country is flood prone as evidenced by the catastrophic flooding of September 2007. Furthermore, although no problems of salinity/sodicity are as yet reported, according to FAO's AQUASTAT, these could occur if saline groundwater is used for irrigation in the semi-arid regions

Flooding is also a considerable in the sub-basins draining from Ethiopia, where in addition gulley formation as a result of inappropriate designs and orientation of traditional drainage. Equally, according to FAO's AQUASTAT, salinity is becoming increasingly encountered in the Awash valley. Although no land has been abandonned as yet, the problems are becoming increasingly acute.

No information has been identified with respect to Eritrea as yet.

As far as Sudan is concerned, ENTRO 2006b mentions that only 43% (800,000ha) of the Gezira scheme is operational due in part to deterioration of the drainage system, including siltation. In fact, in the country as a whole 10650 km of canals are badly silted according to the "Trans-boundary Analysis Final country Report Sudan". In addition, the same source reports that some 4.8 million ha have a problem with salinity or sodicity (2.1 million and 2.7 million ha respectively).

Salinity in the Sudan does not just arise from poor drainage however. According to ENTRO 2006b climate, natural weathering of salt bearing rocks is - in addition to poor soil and water management on irrigation schemes, and poor drainage - the cause of salinity i) on the higher terraces along the Nile, ii) South of Khartoum, iii) North Gezira and iv) along the white Nile north of Kosti.

None of Sudan's drainage water is re-used according to Elzein 2007 who states that all agricultural drainage either evaporates or is returned to the Nile.

Egypt, according to FAO"s AQUASTAT has a National Drainage programme for salinity and water logging control. During 1970's 30-35% of the total Nile Valley/Delta were considered affected by salinity/sodicity according to the "State of Environment Report" cited in ENTRO 2006f FAO's AQUASTAT also states that Egypt's drained area totals 302400ha. This is potentially inconsistent however with another statement, again in the same source which states that salinity and waterlogging has been reduced by some 80% in spatial terms (from 1,200,000 to 250,000ha) as a result of drainage. However ENTRO 2006f states that one method of drainage comprises pumping from wells thereby controlling water tables. This could account for some (but not all of the anomaly).

Egypt is characterised by high re-use percentages, which result in high agricultural productivity in water use (quoted as being 230% in Allen 2001). But once again data is a little inconsistent. For instance in one place FAO's AQUASTAT states that 4 million m^3/yr flow back into the Nile and/or irrigation systems from drainage, this equals "all the drainage water in Upper Egypt". Elsewhere the same source says i) that 4.84 km3/yr of return flow is used for agriculture and ii) that re-use of drainage water totals 10.967 million m^3/yr – although some of this would be via groundwater, it seems large in comparison with the return flow. Nonetheless, despite data inconsistencies, the re-use of drainage water is a serious and desirable practice in Egypt, where ikn fact, according to the Egypt "Environmental Report" it is intended to increase the use of drainage for agricultural re-use. But the need for an appropriate regulatory framework is acknowledged if salinity problems are to be avoided, especially as according to ENTRO 2007a, drainage water is becoming increasingly saline in the Nile Delta (where FAO's AQUASTAT estimates that drainage water in the Nile Delta totals some 14 km^3/yr) due to pesticide residues, wastewater and industrial pollution.

Salinity builds up in fact from the Aswan Dam northwards. The dam is actually partially blamed for increased salinity due to release of silt free water in ENTRO 2007b.

Salinity levels of the water released by the Dam has salinity levels of around 160 mg/l, but this increases downstream as a result of the inflow of water draining from the irrigated fields adjacent to the river (which as we have seen totals some 4 billion m^3 in a typical year). By the time the river reaches Cairo its salinity levels have risen to around 250 mg/l by Cairo, but thereafter this increases dramatically due to domestic/industrial pollution from Cairo and because of intensive agriculture on the Delta. It was estimated that in 1985 salinity levels on the Delat were as high as 2400 mg/l and by 1995 2750 mg/l in general, with peaks of as much as 6000 mg/l in places and even 10000 mg/l towards the coast, but this is likely to be due to saline intrusion ("Environmental Assessment of Eastern Nile Sub-basin" ENTRO 2007c).

Finally, according to FAO's AQUASTAT Egypt salinity levels higher in winter due to less water being used for irrigation

8.3 Coastal interaction

The Nile discharges into the Mediterranean sea, via a delta on the North coast of Egypt. The delta itself is inhabited by over 20 million people which represent about 25% of the population of Egypt and about 12% of the total Nile Basin population. These socio-economic activities in the Nile Delta are dependent mainly on Agriculture, in addition to other fishery and industrial activities.

The coastal interaction of the Nile Delta with the Mediterranean Sea at the downstream end of the Nile River makes the Delta area vulnerable to many risks including impacts of sea water rise due to climate change, coastal sea shore erosion, sea water intrusion to groundwater, potential flooding incidents in case of high Nile floods and associated High Aswan Dam releases, in addition to potential pollution of coastal areas and resulting Nile water and sea water quality degradation downstream a 6000 km river, affecting quality of life, fishery, and tourism in coastal areas.

The ever increasing water demand in the extremely arid regions of the Nile basin like Egypt and norhtern part of Sudan which are dependent mainly on the Nile has resulted in the dire need to reglulate the Nile flow at its downstream to make use of every drop of water. The several dams and regulating structures on the Nile have slightly reduced to some extend the flow of sediments reacing the coastal areas of the Nile Delta which slightly may increased the risk of coastal shore erosion at the interaction zone between the Nile and the Mediterranean Sea.

Several measures have been taken in Egypt to protect the coastal areas and the people living along the Nile from some of the above mentioned risks, including institutional measures such as regulation for enforcing a safe zone from coastal areas and establishing a sector for Shore Protection within the Ministry of Water Resources & Irrigation of Egypt, limiting rice cultivation areas to northern areas to help push sea water interface away to protect the groundwater water aquifer from sea water intrusion, as well as limiting groundwater pumping in coastal areas to reduce potential upconning and sea water intrusion. Other infrastructure measures include installation of breakwaters, channel improvement to the Main Nile Delta branches (Damietta & Rosetta), installation of tail end barrages to prevent backing of sea water into Nile River branches during low Nile flow seasons.

The impacts of climate change on sea water rise can have a great impact on the low lands of the coastal areas in the Nile Delta where a large population may be affected and forced to relocate.

9 Impacts of Climate Change and Variability

Climate change and variability are likely to impose additional pressures on water availability, water accessibility and water demand in Africa. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. The population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively (IPCC 2007). Due to heavy human extraction and high evaporation and evapotranspiration, the Nile river basin and its inhabitants are especially sensitive to climate change. Along its 3,000 km course through arid northern Sudan and Egypt, the Nile loses a huge amount of water to evaporation. This makes water supply extremely sensitive to temperature and precipitation changes.

Analysis of rainfall and river flow records during the 20th century demonstrates high levels of interannual and interdecadal variability. This is experienced locally and regionally in the headwater regions of the Nile and internationally through its effects on downstream Nile flows in Sudan and Egypt. Examples of climate variability are presented from areas in the basin where it exerts a strong influence on society; the Ethiopian highlands (links with food security), Lake Victoria (management of non-stationary lake levels) and Egypt (exposure to interdecadal variability of Nile flows). The mean annual rainfall over the basin is 1200 mm and reaches about 1500 mm at the high lands. 70-75% of the annual rainfall occurs during June-September. The second rain period is Feb-May (Sonbol et al. 2007).

On the Mediterranean coast mean annual rainfall is some 150 to 200 mm, most of it falling in the winter. The air temperature is strongly affected by the sea climate, making the difference between the warmest and coolest months of the year rather limited. In the Delta and Middle Egypt annual rainfall varies between 100 mm in the very north and almost zero in the south. The summer temperature is higher than that in the zone close to the sea, and the winter temperature cooler. Upper Egypt and the northern Sudan as far as Merowe have practically no rainfall and the diurnal temperature range is huge (Nicol 2003). The central Sudan from latitude of Merowe to the latitude of Roseires has an annual rainfall belt from almost zero in the north to between 600 and 800 mm in the south. The rainfall in the south is mostly confined to July and August. The day temperatures during the months of December, January, and February are not unduly hot and the nights are cool. At the same time, the air humidity is low (Nicol 2003). The southern Sudan has rainfall at any time between February and November, and the annual average ranges from 1,000 to 1,250 mm. The maximum temperature is in March and the minimum in July and August. Humidity is low from January to March, but is high at the peak of the rains. On the Ethiopian Plateau annual rainfall varies from 1,200 to 1,750 mm. Since the rainfall in this area equals or slightly exceeds loss by evaporation and evapotranspiration, the Ethiopian Plateau is probably the only area in the Nile Basin where there is an excess or surplus of water. At the height of the rainy season rain falls about three days out of four, but its incidence varies with locality, the maximum being reached usually about the beginning of August (Nicol 2003). The Equatorial Lakes Plateau similarly has a rainfall that depends on altitude and the landscape of the surrounding country. The long-term average annual rainfall on the Lake Plateau (1,200 to 1,400 mm) is about 15 to 20 percent smaller than the annual rainfall in the Ethiopian Plateau (Nicol 2003).

Historical records of Nile floods reveal a strong correlation between low Nile floods and cold summers in Europe, and conversely, high Nile floods and warms summers in Europe (Hassan 1998). Fluctuations in Nile flood levels coincide with climatic changes in the Sahel and even the flow of the Senegal River at the other end of Africa (Hassan 1998). Warmer temperatures increase evapotransporation which in turn cause higher precipitation, leading to higher Nile floods. Climate change clearly influences the size of Nile floods. The long term annual average of

Nile flows between 1872-1986 is about 88 km3/year. The floods typically occur during the months of July, August and September. Below are graphical representations of the average monthly Nile flows and a record of annual Nile flows at Aswan, between 1872-1986.

Mohamed Abdelati, predicts that through the analysis of different GCMs and emission scenarios that considered the extreme change till year 2030, that the probability of wetting (increase of precipitation rates) is higher than drying. The precipitation change showed that there will be spatial precipitation change

on the Nile basin where the range of precipitation change on the Blue Nile will range from –2.14% to 10.65% and the White Nile precipitation will change within a range of –1.43% to 9.94%.

Figure 9.1 **Average Longterm Monthly Nile flows, 1872-1986**

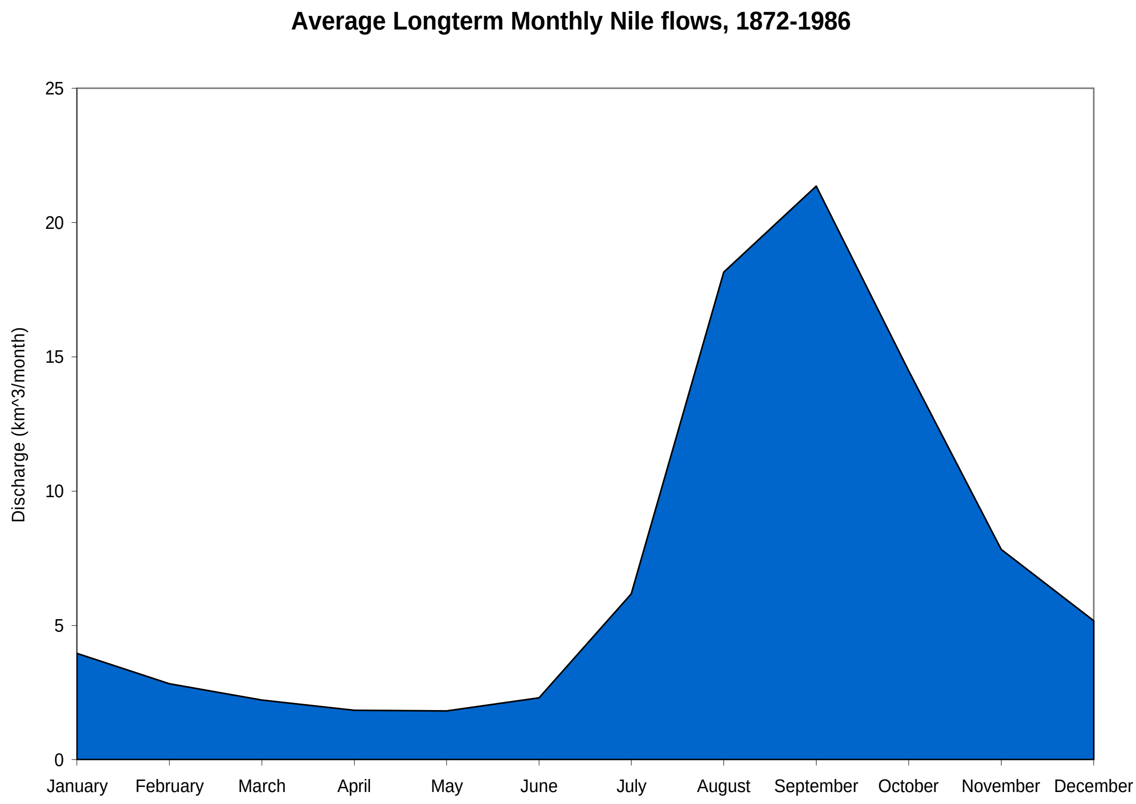
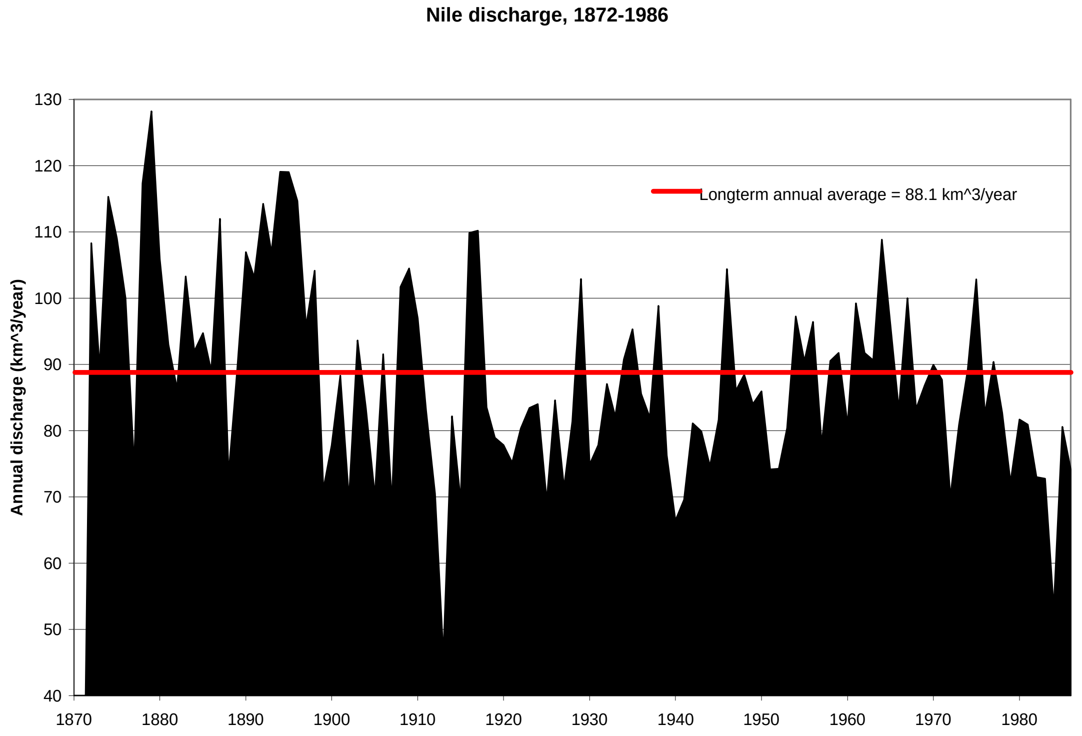


Figure 9.2 **Nile discharge, 1872-1986**



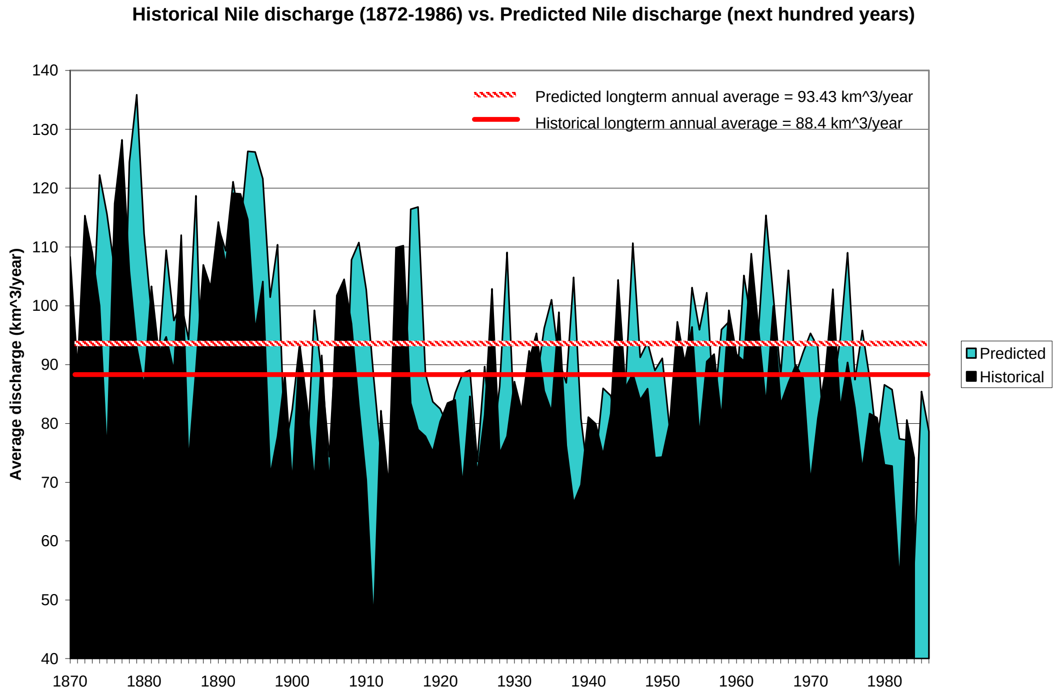
There is a wide disparity in predictions of future Nile flow scenarios. Below are summaries of a few.

(Strzepek et al. 1995) finds changes in runoff from a hydrological model using GCM-based climate change scenarios for doubled global atmospheric concentrations (2xCO2). There is widely diverging pictures of possible future Nile flows: GISS (Goddard Institute for Space Studies, New York, NY) — a 30% increase; UKMO (United Kingdom Meteorological Office) — a 12% decrease; and GFDL (Geophysical Fluid Dynamics Laboratory steady-state, Princeton, NJ) — a 78% decrease. These are postulated for the year 2060. (Conway and Hulme 1996) suggests currently anticipated changes in atmospheric concentrations of CO2 by year 2025 would lead to air temperature increase of 1°C across Nile Basin, leading to increased evaporation loss and slight increase (2%) in rainfall in Blue Nile Basin and slightly larger increase in rainfall (5%) over Equatorial Lakes region, spread fairly evenly through wet and dry seasons. (Yates 1998a) found that Nile water resources declined under GFDL and increased for the GISSA and UKMO scenarios. (Yates 1998b) supports previous findings that changes in precipitation and to a lesser extent temperature over the Nile basin could have serious consequences on regional water resources throughout this large African basin. The 2xCO2 GCM scenarios gave a wide range of changes both in total water yield at Aswan and regional hydrologic changes throughout the basin. Five of six GCMs showed increased flows at Aswan, with increases as much as 137% (UKMO). Only one GCM (GFDLT) showed a decline in annual discharge at Aswan (-15%). Five of six GCMs predict increased precipitation in equatorial Africa. With some GCM scenarios predicting large increases in Nile discharge, there will be a need to increase flood protection, particularly in the Sudan

The majority of past studies predict an increase in Nile flow in the next one hundred years. While the exact increase is difficult to predict, it is likely that the (Johns 2003) studies are the most accurate, given that it uses the latest emissions scenarios data available from the IPCC. Studies assume that temperatures will warm approximately 5.3 K in the next one hundred years, while global mean annual precipitation will increase by 1% per K increase. A best fit to the GCM scenarios outlined in (Yates 1998), is the GFDL scenario, with an average temperature increase of 2.7 K and an average percent change in precipitation of 8.95%, which then corresponds to a 6% increase in the Nile flow measured at Aswan.

For Burundi, The modeling by PANA (2006) of the water resources vulnerability to the climate changes comes to the conclusion that the water resources availability will decrease in the future, when the impacts of the greenhouse gases are neglected. With consideration of the impacts of these gases, the rainfall and the temperature will increase, in fact temporal and spatial changes in rainfall are already reported at the local level.

Figure 9.3 Historical Nile discharge (1872-1986) vs. predicted Nile discharge



Of particular concern for downstream riparian societies in the most arid parts of the basin were the seasonal and inter-annual peaks and troughs. These would effectively control the prosperity of the riparian societies, almost wholly dependent on river flows for agricultural production and food security. For up to eight millennia, the extreme unreliability of flows has preoccupied communities. The varying flow from year to year as well as seasonally has been recorded for thousands of years and the awareness of cycles of lean years followed by years of plenty was part of the way of life of people residing in the lower Nile valley before the filling of Lake Nasser/Nubia in the 1960s. (Sutcliffe and Lazenby, 1994). The key hydrological characteristics of the river are its two major origins: in the highlands of Ethiopia and Eritrea, and in the Nile equatorial lakes region. The former provides the major flow of the Nile north of Khartoum – the Blue Nile – and the latter the far lower and slower flows of the White Nile. While the catchment of the Blue Nile is small relative to that of the White Nile, high rainfall from June to September means that it is by far the greatest contributor to main Nile flows – some 60 percent of the total. The White Nile, by contrast, is derived from rainfall in the equatorial lakes region around Lake Victoria – at 69,500 km2 the world's second largest lake – but provides a mere 30 percent of flows as measured at Aswan. The second major feature of the hydrological system is the huge seasonality of the Blue Nile's flows, concentrated from July to October in a spectacular flood. From the point of view of basin development the main interest in the hydrology of the Blue Nile within Ethiopia is for flood forecasting for reservoir operation and to give warning of possible inundation in Khartoum and in the agricultural areas downstream (Sutcliffe and Lazenby, 1994).

The difference in the two major river regimes is marked: while the White Nile's average monthly maximum (October) and minimum (February) discharges vary only slightly from 1.4 billion cubic meters (bcm) to 1.2 bcm, the Blue Nile and associated rivers (Atbara – which joins the main Nile at Atbara north of Khartoum – and the Sobat which joins the White Nile just as the river emerges from the Sudd) vary greatly from a high of 15.6 bcm in August to just 0.3 bcm in April. A third major feature of the river system is caused by virtue of the river's situation in hot, arid areas where evaporation losses are high (Nicol 2003). By far the most significant losses are in the Sudd in southern Sudan. Between entry and exit the river loses up to 50 percent of its original flow. This loss to the system for Egypt and Sudan has meant significant shortfalls in summer months, when flows from the Blue Nile reach their lowest point. Therefore, enabling greater White Nile flows during this period has important economic consequences, even though it is only a relatively small proportion of annual flows. Reducing this loss was at the heart of attempts to speed up the flow through the Sudd via the Jonglei Canal Scheme.

The north–south orientation of the River Nile on the African continent ensures extreme variability in climate between the extremes of the basin. The Nile Basin receives annually an average rainfall of about 650 mm, or a total of about 1,900 bcm per year. Long-term mean annual flow at Aswan is about 84 bcm per year, making the annual runoff coefficient of the basin around 4.5 percent (Nicol 2003). This figure is small and, for example, is just 10 percent of that of the Rhine. The reason for this is found largely in those parts of the basin belonging to the arid and hyper-arid zones that are large in surface area, and contribute only negligibly to basin runoff. With losses from major swamp areas as well, up to 30 percent of the rainfall the Nile Basin receives in an average year is lost before being used for any purpose. The Nile Basin's climate range varies between extreme aridity in the north (Egypt and Sudan in particular) to tropical rainforest in Central and East Africa and parts of Ethiopia. On the Ethiopian massif, the key contributor of Nile flows, the kiremt rains produce the main June to November spate. This spectacular phenomenon is the combination of three mechanisms: the northward movement of the Inter-Tropical Convergence Zone (ITCZ) (summer monsoon) over the highlands and its subsequent retreat; the tropical "upper easterlies," and local convergence in the Arabian Sea coastal region. The resulting rainfall is often intense, and causes rapid runoff leading to major soil loss (Nicol 2003).

New estimates of Lake Victoria levels and outflows for the period 1870-1895, extending the length of the observed data for Lake Victoria (1896 onwards) by some 25%. Crucially the analysis includes the major flood event of 1878, which anecdotal evidence suggests was the highest since 1860 (and possibly earlier); possibly linked to the El Nino event of 1878, which was one of the strongest of the past few centuries. This is supported by evidence from the Roda Nilometer, which indicates that the flows in 1878/79 were the highest for the previous fifty years or so, and therefore the highest in the nineteenth century.

To assess the implications of these results for future levels and outflows at Lake Victoria, it is necessary to estimate the net basin supply to the lake, which is the sum of the inflows from rainfall and tributary flows, less the evaporation from the lake.

The net basin supply is a true measure of climatic variability around the lake, whereas the lake level and outflow time series are not independent, and are influenced by storage effects in the lake, which can persist for the order of a decade.

A first estimate of the annual net basin, supply can be obtained from the annual storage changes in the lake and the mean annual outflow. Observations suggest that the surface area of the lake only varies by a few percent about a mean value of 67 000 km2, so annual storage changes can be estimated by assuming a constant surface area equal to the mean. End-of-year levels have been estimated by assuming that the annual mean values calculated by the model are indicative of mid-year levels, and assuming a linear variation in levels between years. Comparing the period 1870-1996, studies showed that, during the 1878 event, both the rainfall and net basin supply rose rapidly to an exceptional level, but fell back to very low values in the next two years.

This is in contrast to the 1917 event, which built up over two to three years, and the 1961-1964 event, which arose initially from a rapid increase in rainfall, which was almost sustained for the next two to three years, and was followed by several years of above average rainfall. These three major events were therefore all qualitatively different, and the anecdotal evidence confirms this to some extent: i.e. the 1878 event arose from exceptional rainfall, affecting both the Blue and White Nile basins; the 1917 event arose from heavy rainfall to the north of the lake, with unusually high flows in the Pibor; whilst the 1961-1964 event arose from prolonged heavy rainfall in the Lake Victoria region, but not in the Blue Nile catchment. The smaller increase in levels during the 1890s appears to have been due to several years of slightly above average rainfall.

It is also worth noting that, for all these events, the variations in a real rainfall are not particularly large, with a total range of only 1400-2400 mm year over the period 1870-1998. However, due to the extreme sensitivity of levels to minor changes in rainfall, in terms of levels and outflows, these events appear much more dramatic than suggested by the rainfall data. The statistical characteristics of the rainfall and net basin supply are summarized for several averaging periods, using the standard WMO 30-year periods. In the period 1871-1900, the lake rainfall appears to have been slightly above average, and perhaps slightly more variable than usual. Only the years 1961-1990 stand out as having unusually high rainfall. The estimated maximum lake rainfall and lake levels reached are also shown; according to the model, the lake rainfall reached comparable peaks of 2300-2400 mm in 1878 and 1961, but a much lower peak in 1917.

Annual mean levels in 1878 and 1961 were also similar. However, following the 1961 event, levels took much longer to decline due to the sustained increase in rainfall, and the lake levels more clearly exhibited the quasi-exponential decline expected from idealized models of the lake water balance (e.g. Sene & Plinston, 1994).

In all stochastic models for net basin supply, the frequency distribution gives a useful first indication of the likely range of predicted levels. In terms of future levels, a preliminary conclusion in some studies was that additional 26 years of data (1870-1895) did not greatly change ideas about the natural flow regime of the lake, and stochastic projections of future flows are likely to be similar to previous estimates. The additional 26 years of data therefore provided further evidence that Lake Victoria levels are highly variable, and can both rise and fall rapidly in periods of only a few years. Also, the 1961-1964 event, which at the time was a major surprise to those involved with development of the Nile, can be seen to be consistent with the natural rainfall regime of the region, with a return period which can be tentatively estimated as of the order of 100 years.

10 Water Use Patterns and Infrastructure

10.1 Domestic water supply and sanitation

It states in ENTRO 2007b that the overall the level of physical and social infrastructure, sanitation and infrastructure is low with the exception of the Main Nile in Egypt. This is very much confirmed throughout the relevant baseline literature. Furthermore, where infrastructure in place it is characterised by leakages at levels as high as 50%, and general dilapidation (SCP 2004).

Domestic water supply sources comprise a range of technologies include protected wells, boreholes, springs and shared public and private standpipes while sanitation facilities range from full public sanitation services to the open air.

In **Burundi**, where formal networks are always based on the development of spring water, an inventory compiled in 2006 showed that just around 70% of the rural population has been provided with some sort of water supply service, Table 10.1 refers. However, as seen in Table 10.2, not all of this is serviceable (success in Table 10.2 refers to population coverage not operational infrastructure, also the reader should not that the figure for well facilities in Table 10.1 has been estimated from the figures given in the Burundi country report in order to rectify inconsistencies in the source tables). The Burundi country report blames the fragmented and uncoordinated institutional landscape for the deteriorating situation.

Table 10.1 Rural Water Supply Coverage in Burundi 2006

WATER FACILITY TYPE	N° OF FACILITIES	N° OF SUPPLIED HOUSEHOLDS	COVERAGE (%)
Developed Springs	22,280	579,577	55.0
Public taps	5,717	145,456	13.8
Connected households	2,479	2,479	0.3
Wells	370	10,110	1.0
Total	**30,846**	**737,622**	**70.1**

Table 10.2 Operational Status of Rural Water Supply Infrastructure in Burundi 2006

WATER FACILITY TYPE	N° OF FACILITIES	N° OF SUPPLIED HOUSEHOLDS	SUCCESS %
Operational developed springs	13,282	360,102	62.1
Operational public taps	3,036	83,417	57.3
Operational household connections	2,479	2,479	100.0
Operational wells	205	6,313	62.4
Total	**19,002**	**452,311**	**61.3**

Table 10.3 and
Table 10.4 provide the same information for urban areas, which generally obtain their supplies from springs situated in lowland valleys.

As far as sanitation in Burundi is concerned, formal collection and treatment of solid and other household (waterborne waste) exists only in Bujumbura which is not situated within the NB. Elsewhere, septic tanks (reported as indequate), pit latrines, urban drainage systems and “everywhere in nature” are used.

Table 10.3 Urban Water Supply Coverage in Burundi 2006

WATER FACILITY TYPE	N° OF FACILITIES	N° OF SUPPLIED HOUSEHOLDS	SUCCESS %
Household connection	25,392	288,246	54.5
Public tap	587	220,014	41.6
Total	**25,979**	**508,260**	**42**

Table 10.4 Operation Status of Urban Water Supply Infrastructure in Burundi 2006

WATER FACILITY TYPE	N° OF FACILITIES	N° OF SUPPLIED HOUSEHOLDS	SUCCESS %
Household connection	25,392	288,246	54.5
Public tap	587	220,014	41.6
Total	**25,979**	**508,260**	**42**

It was possible to identify neither quantitative nor synoptic data for **Rwanda**.

For **Tanzania,** the only major water supply infrastructure in the Lake Victoria basin are those that supply the three big towns on the shores of the lake, namely Musoma, Mwanza and Bukoba. The source of water for these towns is mainly Lake Victoria except for Bukoba town which abstracts its from springs and rivers. The design capacities of the intake structures for Musoma, Mwanza and Bukoba are 1.004 m^3/hr, 4.134 m^3/hr and .374 m^3/hr respectively.

In an affort to rehabilitate storage structures so as to provide adequate water supply for human and livestock needs in the country the Ministry of Water conducted a study and came up with the number of reservoirs in need of rehabilitation and of proposed new reservoirs. Table 10.5 summarises the results as they apply to the Lake Basin as detailed in Table 2.2 (Wizara ya Maji, 2002) summarises the results as they apply to Lake Basin according to the Ministry of Agriculture. The number of reservoirs in need of rehabilitation supports the contention that most of them are silted up and/or that their embankment are broken.

Table 10.5 Number of Existing and Proposed Water Supply Reservoirs in the Lake Basin

DISTRICT	NUMBER OF EXISTING RESERVOIRS	RESERVOIRS PROPOSED FOR REHABILITATION	NUMBER OF NEW RESERVOIRS PROPOSED
Sengerema	8	8	2
Misungwi	3	3	5
Geita	7	7	5
Kwimba	22	22	5
Magu	15	15	13
Musoma (rural)	29	27	6
Bunda	14	13	5

DISTRICT	NUMBER OF EXISTING RESERVOIRS	RESERVOIRS PROPOSED FOR REHABILITATION	NUMBER OF NEW RESERVOIRS PROPOSED
Serengeti	26	26	8
Tarime	22	21	4
Bariadi	36	36	-
Maswa	13	13	3
Shinyanga (rural)	12	12	5
Meatu	1	-	2
Bukoba (rural)	-	-	4
Muleba	-	-	8
Biharamulo	-	-	14
Karagwe	-	-	6
Total	**208**	**203**	**95**

It should be noted however, that Maswa, Shinyanga (rural) and Meatu are just partly covered by the lake basin while the districts of Bariadi, Geita and Biharamulo are mostly covered and the rest are entirely covered. Table 10.6 shows the details of big reservoirs, i.e. volume equal or greater than 1 million cubic metres. All the big reservoirs are located within the lake basin.

Table 10.6 Status of the Larger Water Supply Reservoirs in Lake Basin

NAME OF RESERVOIR	DISTRICT	VOLUME (M3)	CONDITION
Bariadi	Bariadi	2,100,000	Water hyacinth problem
Mwalushu	Bariadi	1,575,000	Embankment partly broken
Ngulyati	Bariadi	1,050,000	Silting and the embankment is weak
Bukabwa	Musoma (rural)	2,250,000	Good condition
Kyarano - Butiama	Musoma (rural)	8,000,000	Good condition
Mulebya	Bunda	1,100,000	Good condition
Nyarwana	Tarime	1,000,000	Embankment broken
Tagota - dam	Tarime	1,000,000	Good condition
Nyanalembo	Geita	1,053,000	Silted up
Malya	Kwimba	1,650,000	Almost silted up
Nyambiti	Kwimba	1,350,000	Silted up and embankment partly broken

Other surface water sources include springs, wells, small lakes or swamps, dug wells and ponds. No datas exists regarding the reliability of these sources of water but in most places they are stated to be seasonal, except obviously for Lake Victoria which itself is a source of water for most of the towns and villages in its vicinity.

The entire Lake Basin is characterised by poor sanitation facilities and concomitant diseases such as cholera, typhoid fever and dysentery, intestinal worms, bilharzia and skin infections. In the shore areas particularly the so called fishing beaches or landing sites toilet facilities are rare. A survey conducted in 2005 revealed that defecation in open places including the lake itself is above average in Mwanza and Mara Regions. Table 10.7 summarizes the percentage of responses of the surveyed respondents on the common place for "calls of nature in Mwanza, Mara and Kagera Regions", the three regions riparian to the Lake.

Table 10.7 Percentage of Responses on the Common Places Used for Calls Of Nature

REGION	OPEN PLACES (%)	PIT LATRINE (%)	IN LAKE (%)
Mwanza	29.6	27.1	34.6
Mara	43.9	34.8	~ 60
Kagera	26.4	38	~ 8

Quantitative data for Kenya is largely limited to that contained in MRB 2004 from which the following has been taken.

- Population without sustainable access to improved water source 43%
- Population with access to improved sanitation 87 %

The baseline literature for **Uganda (GoU 2007)** only has synoptic information as follows. Water borne diseases such as dysentery, cholera and typhoid fever remain a leading cause of mortality and morbidity in the country particularly among vulnerable groups like children, pregnant mothers and people living with HIV/AIDS. Water borne diseases are acquired through consumption of water contaminated with fecal matter as a consequence of poor hygiene and sanitation. Many people in the rural areas and to a large extent, peri-urban slum areas, depend on onsite sanitation, predominantly pit latrines, which has contributed to ground water contamination in many parts of the country, especially in Kampala. There have been a number of reported incidents of polluted springs and shallow wells in both rural and urban areas due to faecal contamination. Due to land shortage in the urban areas, some people have also been reported to have emptied their filled up latrines directly in the nearby water bodies and drainage channels. Leakages in old sewers and poorly constructed and managed septic tanks and sewerage treatment works greatly contribute to the contamination of surface and ground water. The situation is even worse in smaller towns without or with non-functional treatment plants, where the sewage is disposed directly into the environment without treatment. This is largely consistent with World Bank 1996 which states that some 60% of Ugandans do not have access to formal sanitation facilities.

There is little information regarding the status of water supply and sanitation in the portions of the **DRC** that lie within the NB. However, it is reasonable to assume that it is extremely limited, given the overall levels of development that characterise the area. This is confirmed by SCP 2004which states that the water supply and sanitation sector has "major shortcomings", although there are plans aplenty, none seem to have been implemented.

With respect to water supply and sanitation, **Ethiopia** was described in World Bank 1996 as being "the poorest compared to any East African Country". The same source stated that only 10% of the entire population benefits from, for instance, formal sanitation services – however, see below for more detailed information.

Similarly, the ENTRO 2006c states that 80% of **Sudan's** population depend on informal groundwater supplies – however, see below for more detailed information.

In Eritrea, the rural areas (which comprise the entire portion of the country draining to the the NB) rely largely on traditional water supply systems, including shallow wells, boreholes and surface waters such as dams and streams. Over 2 million people in the country as a whole rely on informal, often unimproved, traditional sources of water – mainly hand dug wells in or near rivers. There is scope for development in most rural areas for small scale interventions – noting that for larger urban areas, more expensive dams and treatment works are usually required. The water supply points are moreover, often distant from the villages, resulting in laborious and time consuming work for the women who are traditionally responsible for collection of household water. Recent surveys suggest up to 50% of villages in Eritrea rely entirely on unimproved wells or surface water sources for their water supplies. However, most wells and boreholes in Eritrea have been surveyed (using GPS equipment) under the National Water Points Survey (UNICEF funded) and their locations plotted on available mapping. The survey was basic with geographic data taking priority, but plans are in the pipeline to expand the scope of the survey to include type of well, water use and other details.

The various Transboundary Analysis Reports provide some very helpful tables collated water supply and sanitation data on a sub-basin basis. For Sudan the data was compiled in 2002 by the UN and for Ethiopia by the World Bank in 2004. The Tables are adapted below.

Table 10.8 Population % Having Access to Drinking Water in the Blue Nile Sub-basin

STATE	PIPED INTO DWELLING	PUBLIC TAP	DEEP WELL/PUMP	DUG WELL/ BUCKET	RIVER/CANAL	RAINWATER	OTHERS
SUDAN							
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13
Gaderif	12.6	18.8	27.7	13.9	13.8	9.4	3.6
Khartoum	59.8	3.5	29.5	2.4	0.2	1.6	2.9
El Gezira	47.2	14.1	16.6	6.6	12	0.2	3.3
Sinnar	30.2	11.3	32.4	0.6	8.1	9.3	7.6

ETHIOPIA	TAP	PROTECTED WELL/SPRING	UN-PROTECTED WELL/SPRING	RIVER/LAKE/POND	OTHER
Amhara	9.1	12.3	41.6	36.3	0.3
BSG	12.5	5.7	0.2	63.1	0.4
Oromiya	11.2	11.2	34.2	43.1	0.3

In terms of provision of piped water supply the urbanized States of Khartoum and El Gezira are clearly better endowed than the other more rural States. In Ethiopia the rate of protected water supplies (tap and protected spring/well) is similar across all the regional States. Wells and springs are the more prevalent source in the highland Regional States of Amhara and Oromiya, with rivers and ponds the more prevalent in lowland Beneshangul-Gumuz regional State.

Table 10.9 Population % Having Access to Sanitation Facilities in the Blue Nile Sub-basin

STATE	FLUSH TO SEWAGE SYSTEM	FLUSH TO SEPTIC TANK	TRADITIONAL PIT LATRINE	SOAK AWAY PIT	OTHERS	MISSING	NO FACILITIES
SUDAN							
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
Gaderif	--	5.0	31.7	3.1	0	0	60.1
Khartoum	1.1	11.2	73.8	0.9	3.1	0.4	9.5
El Gezira	--	4.2	51.7	2.1	1.7	0.2	40.0
Sinnar	--	2.7	46.6	5.3	2.1	0.7	42.7

ETHIOPIA	FLUSH - PRIVATE	FLUSH – SHARED	PIT - PRIVATE	PIT - SHARED	OTHER		NO FACILITIES
Amhara	**1.6**	**1.2**	**18.2**	**16.2**	**1.1**		**61.7**
BSG	**2.2**	**3.9**	**30.3**	**0.3**	**1.7**		**61.6**
Oromiya	**1.8**	**1.4**	**33.4**	**22.4**	**1.1**		**39.9**

Khartoum with its relatively low and Gaderif with its high rate of "no-sanitation facilities" follow the pattern of piped water provision. With the remaining States the relationship is not as clear. In Ethiopia the rates of no sanitation facilities do not parallel those for protected water supplies.

Table 10.10 Population % Having Access to Sanitation Facilities in the Baro-Akobo-Sobat/White Nile Sub-basins

STATE	PIPED INTO DWELLING	PUBLIC TAP	DEEP WELL/ PUMP	DUG WELL/ BUCKET	RIVER/CANAL	RAIN WATER	OTHERS	NOT STATED
Khartoum	59.8	3.5	29.5	2.4	0.2	1.6	2.9	--
El Gezira	47.2	14.1	16.6	6.6	12	0.2	3.3	--
Sinnar	30.2	11.3	32.4	0.6	8.1	9.3	7.6	0.4
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13	0
North Kordofan	16.3	5.3	20.5	25.4	2.2	13.2	17.1	--
South Kordofan	0.9	1.7	76.6	7.1	0.1	4.9	8.6	--
White Nile	23.1	5.5	10.3	12.4	28.5	7.7	11.8	0.8
NORTH SUDAN	**50.8**	**4.3**	**15.8**	**9.8**	**12.8**	**--**	**6.4**	**0.1**
Upper Nile								
Jonglei								
Equatoria								
Malakal	**3.6**	**1.8**		**0.2**	**94.1**		**0.3**	

ETHIOPIA	TAP	PROTECTED WELL/SPRING	UNPROTECTED WELL/SPRING	RIVER, LAKE, POND	NOT STATED
BS-G Region	12.5	5.7	0.1	63.1	18.6
Oromiya	11.2	11.2	34.2	43.1	0.3
Gambela	16.7	9.8	16.5	56.2	0.8
SNNP	7.6	11.2	30.5	50.1	0.2

Khartoum, El Gezira and Sinner States have rates of piped water and deep wells well above those of Blue Nile, and North and South Kordofan State. Data for other South Sudan States are missing although the town of Malakal has 94% of the population using rivers or canals, which may be indicative of the rates in Southern Sudan.

In Ethiopia rates of protected water supplies vary between 18 and 27% indicating a more even distribution.

Table 10.11 Population % Having Access to Sanitation Facilities in the Blue Nile Sub-basin

STATE	FLUSH TO SEWAGE SYSTEM	FLUSH TO SEPTIC TANK	TRADITIONAL PIT LATRINE	SOAK AWAY PIT	OTHERS	MISSING	NO FACILITIES
Khartoum	1.1	11.2	73.8	0.9	3.1	0.4	9.5
El Gezira	--	4.2	51.7	2.1	1.7	0.2	40.0
Sinnar	--	2.7	46.6	5.3	2.1	0.7	42.7
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
North Kordofan	--	2.9	31.4	1.9	1	0.1	62.6
South Kordofan	--	2.4	48.7	0.3	1.4	0.9	46.4
White Nile	--	4.8	45.7	3.7	2.2	0.5	43.2
NORTH SUDAN	--	7.7	69.2	1.6	1.6	--	19.9
Upper Nile							
Jonglei							
Equatoria							
Malakal		2.1	22.4	4.5	0.6	0.3	70.1

ETHIOPIA	FLUSH - PRIVATE	FLUSH - SHARED	PIT – PRIVATE	PIT - SHARED		NOT STATED	NO FACILITIES
BS-G Region	2.2	3.9	30.3	0.3		1.7	61.6
Oromiya	1.8	1.4	33.4	22.4		1.1	39.9
Gambela	3.0	3.1	13.1	11.7		2.1	67.0
SNNP Region	1.2	0.9	38.1	22.8		1.2	36.0

The pattern in the variation in rates of the population without sanitary facilities is not the same as that of protected water supplies. Blue Nile, White Nile and South Kordofan States have relatively lower rates similar to ElGezira and Sinner, In Ethiopia the rates of population with no facilities are lower in Oromiya and SNNP Regions than in the lowland regions of Gambela and BS-G regions.

For **Egypt**, ENTRO 2007b states that some 98% of the population has access to **improved** drinking water for which the Main Nile is the predominant source, and 68% to adequate sanitation. These figures however should be qualified by the fact that according to Ethiopia's "National Water Development Report" '(GoE 2004), only 47% of Egypt's **rural** population have access to **safe** drinking water.

10.2 Agriculture

Agriculture, much of it under some form of agricultural water management, dominates in terms of its contribution to GDP and rural livelihoods in most of the NB. Unless otherwise indicated, the following information is taken from the country baseline reports.

In **Burundi,** agriculture is the "predominant activity". It provides a livelihood for some 90% of the population, and contributes 60% to the GDP; 95% of the food supply and 95% of the country's export revenues. The country has an estimated cultivable area of 1,400,000 ha, (FAO 2005) although not all of this lies within the NB. Of this, some 215,000 ha is considered to have potential for agricultural water management. According to the latest update of FAO's AQUASTAT (A/STAT), of this total potential some 6,960 ha are under full or partial irrigation; 14,470 ha comprise equipped lowlands and 83,000 ha comprise managed wetlands. Available data does not say how much of this lies within the NB, however, perusal of FAO's 2007 Digital Global Map of Irrigation Areas (I/MAP), suggests that some 30%-50% can be reasonably expected to lie within the basin, this however is inconsistent with FAO 1997 which states that none of Burundi's irrigated area lies within the NB. Typical crops grown include rice, vegetables, sugar cane and other industrial crops.

In **Rwanda,** agriculture also provides livelihoods for some 90% of the population and 93% of the country's exports. The country has an estimated 1,550,000 ha of cultivable land, including manageable wetlands. Of this, some 165,000 ha is thought to have potential for agricultural water management. According to A/STAT, of this total potential, 3,500 ha are already under full or partial irrigation; 5,000 ha comprise equipped lowlands and 94,000 ha comprise managed wetlands. Land and Water Bulletin N° 4 suggests that 2,000 ha of all this lies within the basin. Typical crops grown include cereals, bananas and other fruits.

Tanzania's conomy is also dominated by agriculture which contributes greatly in terms of Gross Domestic Product and the country's export earnings. In 2004 for instance, the sector contributed approximately 51% of foreign exchange earnings and 47% of the Gross Domestic Product. Furthermore, the agricultural sector employs about 80% of the rural population and has strong consumption linkage with other sectors. The country covers an area of 94.5 million hectares of which 44 million hectares are classified as suitable for agriculture and 10.1 million hectares (23%) is being cultivated. The country is endowed with substantial water resources and land with varying levels of irrigation potential. The GoT/Jica 2002 National Irrigation Master Plan (NIMP) of 2002 provides detailed information on the irrigation potential in Tanzania. Total potential area for irrigation development is 29.4 million hectares out of which 2.3 million hectares are characterized as high potential, 4.8 million hectares as medium potential and 22.3 million hectares as low potential. The potential areas are characterized based on the result of study on water resources, land resources and socio-economic potential. At present an area of about 270,000 ha is under irrigation of which 10,000 ha lies within the Nile Basin.

Agriculture is the backbone of **Kenya's** economy, contributing directly 26% of GDP and 60% of the export earnings. It contributes a further 27% of the GDP through links with manufacturing, distribution and service-related sectors. Over 70% of the population live in the rural areas and derive their livelihoods from agriculture (GoK 2007). According to the country baseline report, 38% of **Kenya's** population lives in the NB. Agriculture can be assumed to be their main occupation with typical crops grown in the portion draining to the NB including maize, vegetables and tea. Although the area in question receives the highest rainfall of the entire country and much of the agricultural production is rainfed, it nonetheless represents some 5.5% of the country's area which is under agricultural water management (total 109,618 ha A/STAT).

Available data for **Uganda** is extremely limited, however is known that, as with the other countries in the region, agriculture dominates the economy and is largely rainfed. Even so the country has an irrigation potential of some 90,000 ha (FAO 2005) of which 5,580 ha are under full or partial irrigation (of which only around 64.5% is thought to be operational); 3,570 ha comprise equipped lowlands and 49,780 comprise managed wetlands, all of which lie within the NB.

As far as the **DRC** is concerned, agriculture is of minimal significance in the NB and none of it is irrigated.

Some 90% of **Ethiopia's** population live in the rural areas where 85% of households are dependent on agriculture for their livelihoods. Agriculture itself reportedly contributes some 45% to GDP, although this is now declining (CRA 2006b). The total cultivated area of the country has been estimated to be 10,671,000 ha (FAO 2005), of which 289,530 ha are irrigated (A/STAT). Of this total, some 29% is located in the Nile basin (CRA 2006b). This represents only 6.4% of the potential irrigable area within the NB, which itself is distributed within the sub-basins as shown in Table 10.12 below.

Table 10.12 Total Irrigation Potential Within Ethiopia's Nile Basin

Sub-basin	Area (ha)	As % of total area	Economical Irrigation potential (ha)	As % of total potential	Irrigated area (2001) (ha)	As % of total irrigated area	As % of economical irrigation potential
Abay (Blue Nile)	20,298,900	54%	523,000	40%	47,020	56%	9%
Baro-Akobo-Sobat	7,585,600	20%	600,000	46%	13,350	16%	2%
Tekezze-Atbara	9,440,100	26%	189,500	14%	24,270	29%	13%
TOTAL	**36,881,200**		**1,312,500**		**84 640**		**6%**

Typical crops include cereals, vegetables and tubers, sugar cane and other industrial crops.

Agriculture and agricultural water use are negligible within **Eritrea's** share of the NB.

In **Sudan,** traditional agriculture provides some 56% of agricultural GDP and provides livelihoods for 70% percent of the population; mechanized farming contributes 7% of agricultural GDP but occupies only 0.7% of the population. Irrigated agriculture contributes 22% of agricultural GDP and occupies only 12% of the population (CRA 2006a).

All irrigation takes place in the NB and totals some 1,380,000 ha (of which only some 42.9% is though to be operational: A/STAT). Of this total, over 90% comprises full or partial irrigation and the remainder spate. Typical crops grown include rice, other cereals, vegetables and tubers, fodder, sugar cane, cotton and other industrial crops

Finally there is **Egypt** where agriculture accounts for 16% of GDP, 20% of exports and about 34% employment (CRA 2006c). For all intents and purposes, all agriculture in Egypt is irrigated and totals around 3,422,178 ha of which 3,078,000 ha (or 90%) lies within the Nile Valley where it is all under full or partial irrigation. A wide range of crops are grown, these include rice, other cereals, vegetables and tubers, fodder, sugar can, cotton and other industrial crops, tree crops, other annual and other perennial crops.

10.3 Livestock

There is little hard information concerning livestock water consumption in the Nile, but the importance of he sector is impossible to ignore. The NB is home to some of the largest populations of livestock Africa. Ethiopia for instance has the largest and Sudan the second. Between them these two countries hold one third of the entire livestock population of Africa (over 80 million tropical livestock units LTU - Molden, Amarasinghe and Hussain 2001).

And as well as providing an ancient life support system for the pastoralists that are encountered in much of the NB, livestock represents a significant economic resource. For instance, although not directly relevant to the NB it is interesting to note that a study financed by the UNDP in 1991 (Water Supply for the Nomad's of the Eastern Region – no reference) estimated that the annual value of livestock production in the eastern region was around $800,000! This was largely predicated on livestock exports to the Arabian peninsular; but it is known that intra-regional trade within the NB is also very significant. Egypt for instance is a major importer of livestock products from Ethiopia.

Yet ILRI 2005 confirms a profound nexus between land and hence watershed degradation in much of the NB's livestock producing regions. In this context, it is important to note that ILRI 2005 also states that drinking water comprises only 1% of livestock's water requirement, the balance being necessary for grazing or fodder production.

A typical LTU in the NB needs around 50 l/day for drinking purposes, this alone totals some 1.5 km^3/yr for just Ethiopia's and Sudan's livestock, and as much as 150 km^3/yr including grazing and fodder.

10.4 Fishery

Freshwater fish comprise an important nutrition source throughout much of the NB, and fisheries comprise both culture and capture modalities.

Capture fishery production potential in **Burundi's** portion of the NB varies between around 90 and 110 kg/ha/yr. Large water bodies draining into the NB total some 1,475 ha, suggesting an annual capture of almost 150 tonnes of fish. However, the country also has some 40 ha of culture fisheries, but it is not clear how many of these are situated within the basin.

Details of fishery activities in **Rwanda** have not been identified so far in the study, however, it is noted that 1937 legislation on fisheries and navigation is still in place.

Lake Victoria represents a major centre of capture fishery activity for **Tanzania**, **Kenya** and **Uganda**. Before the introduction of the Nile Perch into the lake in the early 1960's it supported an estimated 400-500 species. However as a result of predation by the perch, this number has dropped to an estimated 200 (Lugomela and Sang). Even so fishing is still one of the major economic activities for communities around the lake. In Tanzania for instance there were a reported 80,053 fishermen in 2002, with a total catch estimated at 200 tonnes, worth some $100 million. Of this total catch, some 37.3 tonnes was exported. The Nile perch moreover is not just used for food, but also for the leather and the brewing industry.

Fishery also takes place along the Mara river for instance, which flows from Kenya into Lake Victoria via Tanzania.

In Kenya moreover, wetlands situated within the Lake Basin also provide capture fishery opportunities. These wetlands include Yala swamp, Nyando, Sondu Miriu, Oluch Kimira (Mogusi) and Gucha. Other smaller wetlands within the basin include Saiwa swamp (on the Nzoia river), Murula swamp (Eldoret) and Dionosoyiet in the vicinity of Kericho as well as seasonal floodplains.

Fish farming is also identified as an emerging economic activity in GoU 2007, although no quantitative information is provided, even though growth of the sector is given high priority by the Ministry of Agriculture, Animal Industry and Fishery.

No specific information concerning fisheries in the **DRC** has proved to be available, nonetheless the Country Report describes Lake Edward as being full of fish and as such an important source of income for lakeshore dwellers.

According to ENTRO 2006d **Ethiopia**'s, Lake Tana is an important source of fish, but "but there is little information on fish species within the basin *(Blue Nile)* and no systematic fish identification has been done so far". The same documents also states that "Studies on the fish and fisheries of the Baro-Akobo-*(Sobat)* basin are limited. No estimates of the number of fishery operations in the region or an evaluation of their catch are available". Some data is available in the same document for the Tekezze-Atbara sub-basin however. In the upper and mid reaches of the sub-basin occasional and part-time fishermen produce 4-1,000 kg of fish per year. Traditional fishing gear catches typically no more than 20-60kg, while improved gear (notably gill nets) produces catches around the 1,000 kg mark. As far as standing waters are concerned, it is estimated that the Lake Tana fishery potential is around 15,000 tonnes/yr, Fincha reservoir (see below) 750 tonnes/yr and so called new reservoirs some 450 tonnes/yr.

There is little to nil fishery potential in the Eritrean portion of the NB.

The importance of fishery activity in **Sudan** however is reflected in the greater level of detail given to it in CRA 2006a where it is stated that the potential for freshwater fish production from rivers, reservoirs and hafirs is estimated to be about 150,000 tons (including 60,000 tons from southern Sudan). Actual production increased slightly from 45,000 tons in 1997 to 53,000 tons in 2001. However, actual production data from the south is difficult to obtain given the remote nature of the fishing areas. From the Blue Nile the majority of the fish are sun-dried whilst 70% of the White Nile catches are consumed fresh. "Tilapia" is the predominant catch, followed by Labeo, Synodontis and Lates .

The inland fisheries are based on the Nile River and its tributaries, which together contribute over 90% of the estimated production potential of the country. The Sudd swamps in the south and the man-made lakes on the White Nile (Gebel Aulia Reservoir), the Blue Nile (Roseires and Sennar Reservoirs), Atbara River (Khashm El Girba Reservoir) and the Main River Nile (Lake Nubia) represent the major fishing localities with respect to fish resource magnitude and exploitation thrust. The Sudd sub-basin alone harbours an estimated fish potential of 75 000 tons/year with a productivity of 110 kg/ha.

The Gebel Aulia Reservoir has a fish potential of 15 000 tons/year and a current production of 13 000 tons/year (86.7%). Roseires Reservoir has a potential of 1 700 tons/year and fish landings of 1 500 tons/year (88.2%). Sennar Reservoir has an estimated fish capacity of 1 100 tons/year and an actual fish yield of 1 000 tons/year (91%). Lake Nubia's potential is 5 100 tons/year, but is able to produce only 1 000 tons of fish annually (19.6%). Production from other Nile River localities has been estimated at 4 000 tons/year.

The predominant fishing gear includes active and passive gillnets, seine nets, trammel nets, long lines, hook and line, cast nets and baskets.

Although the inland fisheries are largely artisanal in nature, a steady increase in market-oriented activities has occurred in recent years; particularly in the White Nile and Lake Nubia. These include aquaculture which in the Sudan dates back to 1953 for freshwater culture.

Finfish is marketed and consumed fresh (63%), sun-dried (28%) or wet salted (9%). The fresh fish is transported from distant fishing grounds to consumption areas in the capital, Khartoum and other towns, either chilled or refrigerated. Sun-dried fish is mostly marketed in rain-fed and mechanized agricultural areas. Wet salted fish (mainly Hydrocyon spp, Alestes spp and Mugil spp) is intended for both local consumption and export. In addition fish by-catch as well as discards are utilized on a small scale for fishmeal production.

Despite all this, the contribution of fisheries to the Sudan GDP is presently marginal. The per caput supply is only 1.64 kg /year, which is mostly obtained by capture fish landings. The aquaculture industry is not developed as yet. Because of their basic characteristics, the Sudan inland capture fisheries are still of a small-scale and semi-industrial nature. If properly managed however, these types of fisheries could satisfy subsistence needs and provide a good margin for larger investments, including in freshwater fisheries.

As with Sudan, Lake Nasser also supports a significant capture fishery on the **Egypt** side; although here, according to the Country Report, a combination of over-fishing, unlicensed boats, illegal equipment/methods and fish smuggling is causing yields to fall.

Earlier, to reduce conflicts among the fisher people the Egyptian portion of the reservoir was divided into five sections based on fishers' areas of origin. By around 1988, even though transport boats had been provided along with refrigerated railway cars to convey fish to lower Egypt, the state of the fishery remained undeveloped with fisherfolk living either in their boats or in temporary shelters at 150 fish camps. Estimated landings were 10,000 tons per annum. Potential of the inshore fishery at full storage level was then estimated at 23,000 tonnes.

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

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

According to 1985 studies, there were 1,683 boats used in fishing in the lake with an average catch of about 10 tons per boat per year. Fisheries studies records 57 different fish species in Lake Nasser, most dominant species are tilapia spp, mainly Nile Tilapia (according to a statement made by the High Dam Development Authority in1981).

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

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

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

Fishery activities, both capture and culture also takes place along the Nile itself and on the delta, but this is small in comparison to the Lake Nasser fisheries. It is reported furthermore, that in the downstream reaches of the river fish are becoming increasingly contaminated with agro-chemical residues, though not yet at levels that would affect human health.

10.5 Energy (hydropower)

There are **currently** fifteen significant hydropower generating facilities in the Nile Basin. The furthest upstream is the Nalubaale Power Station (previously called the Owen Falls dam) in Uganda a short way down the Victoria Nile from its source at Jinga. The rating of the Nalubaale power station is 180MW. Originally it was designed for ten turbines rated at 15MW each (giving a total of 150MW). The station was refurbished in the 1980s to repair the accumulated wear from a decade of civil disorder. During the repairs the output power of the generators was increased.

In 1993 work started on the Owen Falls Extension project, a second powerhouse located about 1 km from the 1954 powerhouse. A new power canal was cut to bring water from Lake Victoria to the new powerhouse. Major construction was completed in 1999 with the first power from the project being generated by two units which became operational in 2000. The extension has space for five hydroelectric turbine generators with three installed as of 2003. Each unit at the extension has a capacity of 40 megawatts. During official opening ceremonies in 2003, the extension was named the Kiira power station.

Finchaa Dam in the Ethiopian highlands, at the head of Lake T'ana and therefore lying within the Blue Nile Sub-basin is the country's largest hydroelectric facility. It was built at a cost of about $40 million and has an installed generating capacity of 133 MW[3] and a potential annual output of approximately 650 million kWh. There are also power generating facilities on the Tekeze river – installed capacity however, has yet to be confirmed.

In the Sudan, the Jebel Aulia dam was constructed in the 1930's for irrigation and flood control purposes. Since then generating equipment with a capacity of 36mW has been installled. Elsewhere, the Roseires Dam has 280 MW; Sennar Dam, 15 MW and El Girba, 12 MW.

Finally, there is the Aswan Dam complex in Egypt which has three separate power houses, one on the High Dam with an installed capacity of 2100 mw, and two on the low dam, Aswan Dam 1 with an installed capacity of 322 mw and Aswan Dam 2, 270 mw.

In addition there are two barrages, Esna and Nag Hamadi, both of which are in the Nile Basin with installed capacities of 86 mw and 5.4 mw respectively (Egyptian Electricity Holding Company 2005/06).

In addition to these larger facilities, some of the country baseline reports also include details of small installations.

In Burundi for instance there are two reported storage based facilities with a combined installed capacity of 26000 kw and 25 run-of-river facilities with a combined capacity of 5,788 kw. And in Kenya there are the Sondu-Miriu project (60 MW) and Tenwek (a mini-hydropower) in Bomet among others in the NB

10.6 Industry and Mining

As can be deduced from **Fehler! Verweisquelle konnte nicht gefunden werden.** below, although somewhat significant in national terms in Uganda industry and mining accounts for very little of the water withdrawn from the NB – ie less than 0.5% (although the DRC is listed as using

3 The consultants were provided with five versions of this figure, this was confirmed by a workshop participant based on personal knowledge, however another workshop participant suggested yet another figure !

16% of its national withdrawal for industry, little if any of this is taken from the NB). However, industry and mining are not only consumers but also polluters of water resources. In Egypt for instance the River Nile supplies some 67% of the country's industrial needs and receives 57% of its effluent, with particularly polluting industries being sugar processing, chemical processing, hydrogenated oil processing, tanning and onion drying. In fact the food processing industry alone is responsible for 50% of the BOD load, while the chemical industry is responsible for 60% of the heavy metal discharges (ENTRO 2006f).

Elsewhere in the NB water consuming or water polluting industries include:

- Tanning, which is particularly polluting yet several of the baseline documents refer to proposals to expand the tanning industry in the basin to add value to the vast livestock populations mentioned above.
- Mining for gold and gems etc. In this respect, the Rwanda country paper mentions that in areas where mining is practised, rivers and lakes often have sediments containing arsenic, lead, mercury and other toxic metalloids and heavy metals. It is not clear however that this results from the mining or is a natural feature of areas with mining potential. It is interesting to note however, the rapid recent growth of the mining industry in Rwanda where From 1999 to 2001, the mining sector played an important role in the national economy in the following proportions: export earnings: 1999: 5.9%; 2000: 12.58%; 2001: 42.64%. It is now the second most important economic sector after coffee production. Similarly in Tanzania an institutional review carried out during preparation of the National Irrigation Policy and Strategy (GoT 2007) referred to mining as a high growth sector. Much of the mining takes place in the Mara catchment, which itself drains into Lake Victoria.
- Printing
- Paper manufacturing
- Mechanical Engineering and metallurgy
- Agro and food processing
- Chemicals

10.7 Navigation

The availability of information concerning navigation is extremely limited within the baseline literature. Accordingly, a synoptic treatment is all that is possible here for the time being.

All that is possible to report for the time being is that as far as the Nile Basin is concerned:

- for Burundi there is no significant water borne transportation within the Nile Basin (although it plays an important on Lake Tanganyika)
- Rwanda has no water borne transportation within the Nile Basin
- There are important transportation networks on Lake Victoria that benefit Tanzania, Kenya and Uganda
- Uganda also shares transportation benefits on Lake Albert with the DRC
- There is no significant water borne transportation in Ethiopia and none in the Eritrean portions of the NB
- In the Sudan however, the river plays a significant role in terms of transportation of both goods and people and is navigable for such purposes as far upstream as Malakal, although it is reported in CRA 2007a that infestation by water hyacinth is beginning to be disruptive to the river transport sector.

- Also in Egypt both the Main Nile and Lake Nasser are important for transport and the former especially so for the many tourists visiting the historic sites between Luxor and Aswan. However it is noted in ENTRO 2006f that the navigable path needs improvement in order to avoid the need to release water from Lake Nasser merely to maintain navigable depths during the winter months.

10.8 Tourism

Tourists, like everyone else, need water for drinking, as an input to their nutrition needs and for hygiene and such like; but because their numbers are small in relation to national populations they have no significance as a special group in this regard, especially as some tourists will already be part of the domestic population in any case. However tourists also need water as amenity and perhaps transportation. And amenity water may be direct as in a lake, or indirect in the form of water to sustain wild life.

It is extremely difficult to apportion such water in a way that allocates water quantitatively to tourism, especially as amenity and transportation is non consumptive, and because water allocation for the sustenance of wild life would not necessarily be probably tourist driven, at least not entirely.

Accordingly this sub-section is limited merely to a synoptic treatment of where tourism is concentrated in the NB and the nature of their interests. Within the NB, there being no beaches, these interests are largely limited to wildlife, angling, scenery, culture and history. As far as wildlife is concerned, this is largely concentrated in **Kenya** and **Tanzania**, and as far as the NB is concerned this means the Maasai Mara/Serengeti complex which is drained by the Mara River for which several initiatives are already in-place to promote its sustainable use. One is the Mara River Water User Organisation, which with the support of the World Wide Fund for Nature, provides a platform for multi-stakeholder management of the rivers resources. These stakeholders include district authorities, game parks, reserves and lodges in both Kenya and Tanzania. The other is the Mara River Transboundary Integrated Water Resources Management and Development Project which is itself being implemented under the aegis of the NBI and is intended to “Establish a sustainable framework for the joint management of the water resources of Mara River Basin; in order to prepare for sustainable development oriented investments that will improve the living conditions of the people while protecting the environment” (MRB 2004).

Tourism in **Uganda** is of limited interest in this context, as it is in **Burundi** and **Rwanda**; and in the NB portions of the **DRC** it is all but non-existent. In **Ethiopia** however, tourism is of increasing significance. Interests include scenery, amenity, culture and history, all of which are represented in the Nile Basin. The highlands for instance offer excellent trekking opportunities, while Lake Tana and its downstream waterfalls are popular amenities. Equally Axum, Gondar and Lalibela, all of which are located within the NB are rich in history and culture.

Tourism in **Eritrea** is very limited, in its infancy and effectively limited to the Dahlak archipelago in the Red Sea and hence of no relevance here.

Similarly, tourism in **Sudan** is also limited. Even so, the sector is represented at Ministry level in the Ministry of Environment and Physical Development. All of the country’s game reserves and some forested areas have high potential to serve the development of ecotourism; but insufficient and inadequate infrastructure remains a big constraint. Ecotourism in forests in Sudan is still a very small component of the world's huge Travel and Tourism Industry, but at the local level, ecotourism in forests and parks has begun to gain significant interest. Tourists, mainly Arabs, come for sport hunting for instance in the Butana plains (which lie within the Tekezze-Atbara and Blue Nile sub-basins) and River Nile State. Equally, it is noted that the Jebel Aulia reservoir (see next sub-section below) has become a popular weekend retreat for residents of Khartoum.

Egypt of course has a major tourist industry where it is the country's main source of hard currency. Although beach holidays on the country's Red Sea coasts are rapidly increasing in popularity, the historical monuments along the Nile in Upper Egypt, and at Abu Simbel on the South West shore of Lake Nasser continue to attract vast numbers of tourists each year. For them the river is as important for transportation between the historic sites, and for the simple pleasure of cruising, as it is and has been for food production for at least 5000 years.

10.9 Water storage

Given the large number of small, informal storage structures that are encountered all over the NB where they are used for stock watering, domestic water supply and irrigation it is impossible to estimate either the number of storage structures or the amounts stored by them.

Accordingly, and because it has not been possible to identify basin-wide information at the detail of Table 10.5 above, it is been decided to limit this section to a brief summary of the large structures, that is to say, structures storing more than 1 km^3 of water. According to FAO 2005 there are 6 such structures. They range in height from 22-111m with storage ranging from 0.9 – 162 Km^3 with a total storage of 231.9 Km^3 and are used for irrigation and/or hydropower generation.

The largest of these dams by far is the Aswan High Dam which accounts for just under 70% of the total volume stored by the NB's big structures.

The other dams are situated in Sudan and Ethiopia, these are:

- Jebel Aulia – Sudan, which has a design storage of 3.5 km3, of which 100% is still live (as advised). The dam was originally intended for irrigation and flood control; but has since equipped for hydropower as mentioned above.
- Sennar- Sudan, which has a design storage of .93 km3, of which only .37 km3or around 40% is now available (MIWR 2006)
- Roseires – Sudan, which has a design storage of 3.024 km3, of which only 1.92 km3 or around 63% is now available (MIWR 2006)
- El Girba – Sudan, which as a design storage of 1.3 km3, of which only .6 km3 or around 46% is now available (MIWR 2006)
- Finchaa – Ethiopia, which has a maximum storage of 900 million m3 and is used for hydropower generation.

In addition there is also the Owen Falls Dam in the Uganda a short way downstream of the emergence of the Victoria Nile, however there is no storage involved.

10.10 Total water withdrawal

The data available so far has not permitted an assessment of total water withdrawals within the NB. However, the following table, which has been taken from FAO 2005, indicates water withdrawals by sector by country and thus provides an indication. Every effort will be made to focus this onto the NB later in the DSS study. Given however, i) that almost 90% of the withdrawals take place in Sudan and Egypt where the vast majority of the water is in fact taken from the Nile, and ii) that NB withdrawals from the other countries are negligible – especially those such as Tanzania, Kenya and Eritrea for which the NB represents only a small portion of the total area - Table 10.13 serves well enough for now. However, because definitions of water withdrawals vary according to use and user, it is necessary to make clear the definitions used in FAO 2005 and hence which drive the table provided here.

Thus:

Water Withdrawal for Agriculture: is defined as "the annual quantity of water withdrawn for irrigated agriculture. It includes irrigation and livestock watering….Like domestic and industrial water withdrawals it includes conveyance losses, consumptive losses and return flow. It does not include water to be reserved for uses with a low consumption rate, such as navigation, recreation, mining, cooling of power plants etc." It also does not include water used for rain-fed agriculture, natural vegetation, forests, or any other green cover.

Water Withdrawal for Domestic/Municipal use: is defined as "the annual quantity of water withdrawn for domestic/municipal purposes. It is usually computed as the total amount of water withdrawn by the public distribution network. It can include withdrawal by any industries connected to the network".

Water Withdrawal for Industry: usually refers to "self-supplied industries not connected to any distribution network".

Table 10.13 Total Water Withdrawals

COUNTRY	YEAR (of data)	ANNUAL WATER WITHDRAWAL million m3							
		AGRICULTURE		URBAN USE		INDUSTRY		TOTAL	
		Volume	% of total	Volume	% of total	Volume	% of total	Volume	% of basin
Burundi	2000	222	77%	49	17%	17	6%	288	0.25%
Rwanda	2000	102	68%	36	24%	12	8%	150	0.13%
Tanzania	2002	4632	89%	527	10%	25	0%	5184	4.44%
Kenya	2003	2165	79%	470	17%	100	4%	2735	2.34%
Uganda	2002	120	40%	134	45%	46	15%	300	0.26%
DRC	2000	112	31%	186	52%	58	16%	356	0.30%
Ethiopia	2002	5204	94%	333	6%	21	0%	5558	4.76%
Eritrea	2004	550	95%	31	5%	1	0%	582	0.50%
Sudan	2000	15500	93%	987	6%	258	2%	16745	17.41%
Egypt	2000	59000	92%	5300	8%	4	0%	64304	55.07%
TOTAL								**116771**	

FAO Water Report N° 29 "Irrigation in Africa in Figures", with updated figures for Sudan from Sudanese comments on Draft IR

11 Institutional Assessment

11.1 Water Policy and Reform Process

Policy development in the water sector is a highly complex process that is influenced by many different constituencies of interests that attempt to influence the outcome of the formulation process. These interests are imbedded in institutions inside and outside the public water sector. Commonly a distinction is made between endogenous and exogenous factor that influence the institutional change process. Endogenous factors are related to water scarcity, water quality, public service performance deterioration and financial constraints issues. Exogenous factors are related to developments at international and national level and technological progress.

The policy contents vary considerable according to the national physical conditions, agendas and institutional arrangements. Land, water and nature conservation form a focus of water and environmental policies in the riparian states in the Upper river basin. Increasingly attention is paid the potential role of water resources for generating socio-economic development and enhancing food security as part of a poverty alleviation strategy. Efficient use of water resources, matching supply and demand and water quality form the focus of the riparian states in the lower river basin. In the lower basin the management structures are more hierarchically organized than in the upper basin, which is commonly explained on the basis of the water distribution function

The discourses in the global water platforms since the early 1990s have affecting policy development in the Nile Basin. In all countries apart from DR Congo (2005) water policies are either in place, drafted, completed or awaiting implementation. The focus of the water and environmental policies differ for the Upper and Lower Nile Basin. These policies introduce new institutional arrangements that aim to establish consistent divisions of mandates and collaboration mechanisms within and between ministries directly or indirectly involved in water resources management. The policies also aim for enhancing the role of the private and voluntary sector in the formulation, design and management of water related initiatives.

In all countries in the Nile Basin, water resources management mandates increasingly are assigned to one ministry that covers both water resources management and public services provision. Another trends is that the constitutional and organizational functions are divided between the central ministry and water resources management authority organized along the hydrological boundaries of river basins. This prevents conflict of interests between the government function to protect the public interest and the operational function of service provision. Still another trend is that these public authorities have consultation platforms with public, private and voluntary organizations engaged in water resources management for coordination of initiatives and for consultation on important water resources management decisions.

The riparian states are experimenting with complementing top-down policy approaches with bottom-up planning approaches. All governments are supporting participatory processes at local level to orient the public sector services in the water sector stronger on the demands of the voluntary and private sectors. The management responsibilities for water supply and irrigation systems at local level get increasingly attention of the water administration because experiences show that beneficiaries care better and contribute more to the management of the systems if they share in the ownership.

Below the main processes of the policy development process in the riparian states are presented. The trends in these developments are quite similar however the pace and focuses of the policies differ with the differences in physical and socio-economic contexts of the riparian countries. The NBI report on Baseline and Needs Assessment of National Water Policies, the NBI DSS country baseline reports, and the interviews with the resource institutes form the sources for this institutional assessment.

11.1.1 Egypt

Egypt is one of the countries facing great challenges, due to its limited water resources represented mainly by its fixed share of the Nile water and its aridity whereby its main water resources comes from the Nile, and originating outside its boundaries. Egypt prepared its first water resources policy after the construction of the Aswan High Dam in 1975. The policy has regularly been reviewed and updated. In 1993 the new water policy included several strategies to ensure satisfying the demands of all water use sectors.

In 2004 the Ministry of Water Resources & Irrigation (MWRI) formulated the National Water Resources Plan (NWRP) that embraces the concept of Integrated Water Resources Management (IWRM) through a policy for dealing with the water scarcity challenges that will be facing Egypt in the 21st century. The NWRP provides specific actions in the form of an investment plan up till the year 2017. The current challenge is how to mobilize the required financial resources to implement the NWRM.

The NWRP overall Policy Objective is:

- To support the socio-economic development of Egypt on the basis of sustainable management of water resources while protecting the natural environment through the:
- Supply drinking water and provision of sanitation services according to standards and targets on a cost recovery basis while ensuring the right to basic requirements to all people
- Supply of water for industrial purposes and provision of sewage treatment facilities on a cost recovery basis
- Supply of water for irrigation based on a participatory approach and cost recovery of O & M
- Protection of the water system from pollution, based on a polluter-pays principle and the restoration of water systems, particularly in the ecologically important areas

In effect, the NWRP aims to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country. It includes different structural and several non-structural measures. Structural measures include: irrigation structures rehabilitation to minimize water losses, improvement of irrigation systems (branch canal and tertiary level), cropping pattern shifts to reduce agriculture water consumption, use of water saving devices in land reclamation areas and urban water uses, reuse of agricultural drainage water, reuse of sewage water, use of groundwater, desalination of brackish water and sea water, and water harvesting of rainfall and flood water. The non-structural measures include the expansion of water users' organizations, the promotion of public awareness programs, the involvement of stakeholders, improvement of legislation, and institutional reform.

11.1.2 Sudan

The water resources management mandates used to be spread over various water related ministries at federal level. The establishment of the Technical Water Resource Organ in 1992 and the National Water Council in 1995 facilitated the integration of all water resources sub-sectors. The Organ and Council adopted an IWRM concept and recommended the formation of a Federal Ministry of Irrigation and Water Resources (MIWR) that became responsible for developing policies, strategies, legislation and plans for developing the national water resources.

The MIWR formed in 1999 a multi-disciplinary and multi-sectoral committee to review, integrated and update the 1992 Water Policy. The committee prepared a preliminary draft that was discussed with the stakeholders and the water related federal ministries and state governments. A revised draft in which the comments had been incorporated was presented to the Council of Ministers, however it failed to obtain their approval. A Federal Committee prepared thedraft Water Policy 2007 which is currently reviewed by the Council of Ministers..

The general objective of the Sudan National Water Policy Draft of 2000 (SNWP) is to ensure that Sudan's water resources are properly managed, protected and efficiently utilized for the benefit of the Sudanese population. The main policy principles of the SNWP are:

- Water is a scarce and valuable commodity which has to be equitably, economically and efficiently used;
- Access to water for basic human needs is the highest priority in the development of water resources;
- Development of water resources must be demand-driven and the management should be undertaken at the lowest appropriate level;
- Development and management of water resources, and the operation and maintenance of water services must be economically sustainable through the recovery of costs from those who benefit;
- All water, including surface and groundwater form part of the hydrological cycle and should be managed in an integrated manner;
- Water resources management effects everybody and should be undertaken by the participation of relevant stakeholders; and
- The development of water resources will be undertaken in order to maximize its benefits in the public interests while ensuring minimum adverse impact on the environment.

The SNWP aims at public institutional arrangements at federal and state levels that are integrated, accessible, efficient and transparent whilst avoiding duplication of functions and responsibilities.

11.1.3 Ethiopia

The Federal Ministry of Water Resources formed a multi-disciplinary committee that got the task of preparing a comprehensive and integrated Water Resources Management Policy. The committee had representatives of the various Federal Ministries involved in the water sector and of the State Governments. The draft policy document was in-depth discussed with representatives of the regional Bureaus of Water Resources Development and stakeholders of the private and voluntary sectors involved in the water sector.

The general objectives of the policy are:

Development of the water resources of the country for economic and social benefits of the people on equitable and sustainable basis;

Allocation and apportionment of water, based on comprehensive and integrated plans and optimum allocation principles that incorporate efficiency of use, equity of access and sustainability of resource;

Managing and combating drought as well as other associated slow onset disasters through efficient allocation, redistribution, transfer, storage and efficient use of water resources;

Combating and regulating floods through sustainable mitigation, preventions, rehabilitation and other practical measures; and

Conserving, protecting and enhancing water resources and the overall aquatic environment on sustainable basis.

The overall objective of water supply and sanitation policy is to enhance the well-being and productivity of the Ethiopian people through the provision of adequate, reliable and affordable clean water supply and sanitation services that meet the livestock, industry and other water users' demand. The overall objective of the irrigation policy is to develop the huge irrigated agriculture potential for the production of food crops and raw materials needed for agro-industries in a sustainable way.

Water Resources Sector Strategies have been developed and short-, medium, and long-term sector development programmes have been prepared for the period 2002-2016. The strategies include; the financing of water resources management and development, the creation of an enabling environment, trans-boundary rivers management; stakeholders participation and gender mainstreaming; disaster prevention and public safety, and environmental health standards.

11.1.4 Kenya

The Water Act 2002 granted the overall responsibility for water management in Kenya to the Ministry of Water Resources Management and Development (MWRMD). The Water Act introduced key reforms to the legal framework for the management of the water sector in Kenya which ware: a) separation of the management of water resources from the provision of water services: b) separation of policy making from day to day administration and regulation; c) decentralization of operational functions to lower level state organs; d) the involvement of the non-government entities and communities in the form of Water Resources Users Associations to manage water resources and provide water supply and sanitation services.

The Water Master Plan (1992) provided the basic policy framework for Kenya. The plan was updated in 1998. The two semi-autonomous bodies that have been established for the organizational functions of water resources management and water services delivery prepared the National Water Resources Management Strategy and the National Water Services Strategies (2005-2007). The overall goal of the NWRMS is to eradicate poverty through the provision of potable water for human consumption and of water for productive use. Specific goals of the strategy are: to improve equal access to water resources for all Kenyans; to promote integrated water resources planning and management at catchment basis; and to enhance the availability of water resources of a suitable quality and quantity.

11.1.5 Uganda

The Government of Uganda created through the National Environment Management Policy (1994), the Water Statute 9/1995 and the National Water Policy (1999) a policy framework for the water sector. The policies have strategies to enhance property rights, to promote environmentally sound land use, to enhance water resources conservation and management; to improve wetland management, and to apply environmental economics and incentives.

The National Environmental Statute 4/1995 is the principal law governing environment management and conservation in Uganda. The objective of the act is to promote sustainable development by:

1. Integrating environmental requirements in all planning and production processes and;
2. Ensuring that renewable resources are optimally used through reduced waste, use of appropriate technology and finding of alternatives to present use of resources.

The statute established the National Environment Management Authority, which in consultation with the leading agencies, is mandate to issue guidelines and prescribe measures and standards for the management and conservation of natural resources and the environment.

The Water Statute 9/1995 has the objective to allow for the orderly development and use of the water resources for domestic, agricultural and industrial purposes in a manner that minimizes harmful effects to the environment. Domestic use included irrigation of subsistence gardens not exceeding 0.5 ha. Extraction of water from surface or ground water is prohibited unless authorized.

The National Water Policy proclaimed the formation of a central authority, being the Ministry of Water, Lands and Environment, whose role is to initiate national policies, to coordination between the line ministries, overseeing compliance and to provide technical support services. The policy also aims for enhancing the role of the private and voluntary sectors through the formulation of policy committees on environment and water at national and local level. These committees aimed for active involvement of local authorities, private sector and NGOs in the development and management water supply and irrigation systems.

Uganda has developed its framework for water resources management consisting of national legislations and by-laws for promoting sound water resources management and constrain potentially harmful practices. The Water Resources Regulations, Water Supply Regulations and Waste Water Discharge regulations are all in place.

11.1.6 Tanzania

The new National Water Policy (NAWAPO) of July 2002 is the outcome of a review of the national water policy of 1991. The review was carried out under the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) and the new policy incorporated the principles of IWRM that were initiated by the Dublin Water Conference.

In July 2002 the Government of Tanzania issued the National Water Policy whose main objectives were to establish a comprehensive framework: for sustainable development and management of water resources and for participatory agreements on the allocation of water uses. The policy incorporated the decentralization drive that was launched by the Local Government Reform Programme. The Ministry of Water became responsible for the constitutional and organizational function and the operational function was delegated to the Local Government Authorities. Basin Water Offices were established that coordinate the water resource management between the Regional and Local Government authorities at river basin level.

In February 2005 the Government of Tanzania issued the National Water Sector Development Strategy 2005 to 2015.

11.1.7 Rwanda

The Government of Rwanda formulated it first National Policy on Water Management in 1994[4]. The mandate of water resources management resorted under various ministries (Agriculture and Public Works) before it was brought under the Ministry of Lands, Environment, Forests, Water and Mines (MINITERE). The policy formulation process reflected global policy changes and opened the sector for public, private and voluntary sector partnerships and references were made to Integrated Water Resources Management (IWRM) principles.

In 2004 the Government of Rwanda brought together the water related ministries, donors, NGOs and representatives of the regions and private sector to examine different policy options for the water management challenges. The discussions resulted in a water sector policy document with merging the water sector with lands environment and forestry sectors under MINITERE. The water sector policy was agreed by the Council of Ministers in October 2004.

The new water policy introduces an institutional reform process in which a National Commission of Water, interdepartmental coordination, basin and catchments committees, and local water users associations are foreseen to be established. The water unit in the ministry will only involve in the constitutional function. For the organizational function public authorities are established and coordination platform will be created at regional level. The public sector at sub-national level is expected to collaborate with the voluntary and private sector to manage the water resources and to provide water and sanitation services. The existing informal water users groups that manage local water resources, will be organized into catchment committees and water user associations to ensure participatory processes in the planning and management of water projects and programs.

11.1.8 Burundi

The Government of Burundi formulated it first National Master Plan in 1992. In 1999 the Government of Burundi formed a multi-sectoral working group that had as task to develop a water resources management policy. The National Water Policy (NWP) and Strategic action plan was completed in 2001, and the Action Plan indicated objectives, actions, performance indicators, institutional responsibilities, budgets and an implementation calendar. The Ministry of Land Management, Environment and Tourism was the overall coordinator, and the Geographical Institute of Burundi was the technical coordinator of the Action Plan. The Action Plan anticipates participation by public sector and local communities through communal administration. However the NWP has never been presented to the Parliament to be accorded to a legal status.

The National Water Policy objective was to achieve manages the national water resources in an integrated and sustainable manner. The guiding principles were:

1. Supply save drinking water to accordance with the demand of the sectors;
2. Consider water as an economic resource for which the management costs have to be covered by the water uses (agriculture, fishing, industry, energy); and
3. Protect the water resources from pollution, overexploitation and wastage.

The NWP defined rivers, lakes, springs, groundwater, swamps permanently covered with water, islands, hydraulic structures constructed for the purpose of public benefit as public domain resources. These public domain resources have to be managed by the Ministry of Land Management, Environment and Tourism. No water intake or water effluent as well as the related water structures can be built in this public hydraulic domain without an authorization or a concession of the national water administration. However water can be abstracted freely from the ground or surface water for domestic purposes (human food supply, hygiene, washing, plant and animal production for domestic consumption).

The law also establishes a priority order for the different water uses. Domestic water use enjoys the highest priority, followed by agricultural uses. The later cover water demands of livestock, fisheries and irrigation. These uses are followed by industrial, environmental and recreational water uses in declining order of priority.

The holders of the water use rights have to use the water in a rational and economic way as well as to respect the rights of the other legitimate users. The water administration manages the water release of reservoirs on the basis of water needs, hydrologic and meteorological data and can decreased the discharge in case of water shortages. A concession doesn't guarantee that the water is made in case of shortages.

The Government of Burundi has also developed an environmental legislation through Codes for specific sectors. The Environmental Code provides a basis for enviromental management. The Forestry Code provides a basis for the entitlements and sustainable management of forest resources. The Land Code provides a basis for entitlements and sustainable management of land resources. There are also statutory decrees for the management of national parks and nature reserves and for the exploitation of mines and peteroleum reservoirs.

11.1.9 DR Congo

The Government of the Democratic Republic of Congo has no unified official water policy in place. Efforts to develop a water policy or a water code with support of UN-organizations have been less successful. Currrently these efforts are proceeding by the National Action Committee on Water and Sanitation (CNAEA) with GTZ support. There is not single organization responsible the governance functions of water resources management. The functions are shared over various Ministries and the Directorate of Water Resources within the Environmental Department of the Ministry of Environment, Water and Forest is responsible for the development of water policies. However the administrative and managerial capacities of the directorate are limited for its constitutional function.

The National Action Committee on Water and Sanitation is responsible for coordination between the ministries and for balancing competing interests in water uses. The committee cannot take the function of water administration that has overall responsibility. The Committee could take an advisory role, however the compromises between conflicting interests would require an organization that has a constitutional mandate.

11.1.10 Institutional Arrangements

All riparian countries have made efforts to bring water resources management under one ministry using an IWRM concept. The water resources management function is increasingly organized at river basin level, which have different consequences for the riparian countries in the Upper and Lower Nile River Basin. In the Upper Nile River Basin the riparian states have Nile River tributaries on their territories, and in the downstream Nile Basin that directly depend on the Nile River for water resources management. In the upstream Nile countries the water resources management institutions are increasing organized at sub-river basin level, while in the Lower Nile Basin they are organized at river basin level. Consequently the institutional structures of the water sector in the downstream Nile Basin are more hierarchically organized than in the upstream Nile Basin countries.

The water resources management and water service provision functions are in some riparian states in the same ministry (Ethiopia, Sudan, Kenya, Uganda and Tanzania) and in others in different ministries (Egypt, Rwanda, Burundi and DR Congo). For the institutional assessment a distinction is made between the constitutional, organizational and operational function of water management[5]. Merging the constitutional function for water resources management and service provision has advantages for dealing with water distribution and water quality issues. It enhances the coordination and collaboration between the water related ministries if one ministry has the constitutional function.

In all riparian countries there is a trend towards the decentralization of irrigation and water supply services to the lowest management level. Some riparian countries initiated a radical public sector reform that decentralized the operational function for services provision to the lowest administrative level (Ethiopia Kenya, Uganda, and Tanzania). In other riparian state the administrative reform processes are more gradual and are preceded by pilot projects that are implemented with support of international development organizations.

For irrigation and drainage development the Ministries of Agriculture become increasingly important for service provision to the private and voluntary sectors. In all riparian states the Ministry of Agriculture provide technical support to small-scale irrigation schemes and community managed tertiary irrigation systems. Large-scale irrigation schemes are managed by Irrigation Departments of Irrigation Boards and these are facing managerial and financial constraints. Participatory irrigation experiments are initiated in which both ministries have to collaborate.

For the electricity sector the ministries take care of the constitutional and regulatory functions and public- and private sector companies for the organizational and operational functions. The planning and management of the generation, transmission and distribution of electricity is in all riparian countries the mandate of public-sector companies. There are attempts to enhance the role of the private sector for investments in hydropower generation, however the interest is still limited. In some riparian states the electricity companies manage only the hydropower plant and in other they manage the reservoirs and the powerhouses.

There are some regional projects for the management of large water bodies. The Lake Victoria Environment Management Project (LVEMP) was formed in 1998 as a regional initiative of the East African Community (EAC), which has as objective to coordinate the management of the environment in the Lake Victoria. The background formed the declining fish catches and the deteriorating water quality. The first phase of the project (1998-2005) was implemented in all three riparian state of Lake Victoria. Currently the project is in a bridging phase for phase two, which is expected to start early 2008. The DR Congo and Uganda are collaborating in the Lake Albert and the Lake George and Edward Basin Organizations.

11.1.11 Egypt

The Ministry of Water Resources and Irrigation (MWRI) is the key institution for water resources management in Egypt. Since the water resources system in Egypt is almost totally dependent on a one-river system, being the Nile, a somewhat centralized control on its management at the national level is needed. The Irrigation Directorates then have an important role in water distribution, irrigation system protection, and water pollution prevention at the sub-national level.

The National Water Research Centre (NWRC) with its 12 Research Institutes represents the research arm of MWRI which perform policy-oriented and applied research including modelling of dam operation, crop water requirements in different agro-ecological zone, groundwater potential, hydraulic impacts of structures, sedimentation regimes, drainage water quality management, and

[5] The constitutional function covers tasks and competencies needed to set rules, to establish institutions and formulate policies. The organisational function covers tasks and competencies needed to develop strategies as logical combination of individual measures and to organise the implementation thereof. The operational function covers the total tasks and competencies to carry out strategies.

others. NWRC includes also a Strategic Research Unit (SRU), and a Central Laboratory for Environmental Quality Monitoring (CLEQM).

The Planning Sector of the MWRI is responsible for the overall water resources planning in Egypt. The Nile Waters Sector, and the Aswan High Dam Authority of MWRI are respectively responsible for trans-boundary water management, and the management of the Aswan High Dam. The Egyptian Public Authority for Drainage Projects is responsible for the construction and management of the public-owned agriculture drainage systems. The Egyptian Public Authority for Shore Protection is responsible for the coastal shore protection.

Table 11.1 Key institutions involved in the water sector of Egypt

Constitutional function	Organisational function	Operational function
Ministry of Water Resources and Irrigation (MWRI)	Nile Water Sector, MWRI	Irrigation Directorates at sub-basin level, MWRI
Ministry of Agriculture and Land Reclamation (MALR)	Planning Sector, MWRI	EPADP Drainage Directorates at sub-basin level, MWRI
Ministry of State for Environmental Affairs	Strategic Research Unit, National Water Research Centre (NWRC), MWRI	Irrigation Improvement Sector, MWRI
Ministry of Housing & Urban Development (MHUD)	Reservoirs & Grand Barrages Sector, MWRI	Holding Company for Water Supply and Sanitation
Ministry of Electricity & Energy (MoEE)	Egyptian Public Authority for High Aswan Dam, MWRI	Egyptian Electricity Holding Company
Ministry of Finance	Egyptian Environmental Affairs Agency (EEAA)	Irrigation Advisory Services
Ministry of Economic Development	Nile Research Institute, NWRC	Land Reclamation Directorate
Ministry of Investment	Hydraulic Research Institute, NWRC	Nile Protection Sector, MWRI
Ministry of Local Development (MoLD)	Water, Land, & Environment Research Institute, ARC, MALR	Agricultural Development Companies
Ministry of Foreign Affairs	District Water Boards	Water users Association and Branch Canal Water Users Associations

The Irrigation Department within MWRI includes several sectors including the Reservoirs and Grand Barrages Sector, which is responsible for the management of all barrages, reservoirs and major water structures. The Irrigation Sector is responsible for the management of public owned irrigation systems up to the level of the tertiary units. Informal irrigation groups manage the private owned tertiary irrigation systems.

The Irrigation Improvement Sector is responsible for the improvement of water use efficiency and water savings in the branch canals and tertiary irrigation systems, and currently concentrates its efforts on the downstream command area of the Nile Delta. It includes Irrigation Advisory Services, which together with the On-farm Water Management Section of the Ministry of Agriculture and Land Reclamation provides managerial and technical support to the water users organizations. The Horizontal Expansion and Projects Sector is responsible for any new public owned irrigation infrastructure required for delivering surface water for the newly developed land areas. The Ground Water Sector is responsible for the control and regulation of groundwater use through assessing potential and issuance of well drilling licences.

The Water Quality Unit of MWRI works on policy issues, monitoring systems, indicators and reporting mechanisms related to water pollution and protection of the water resources quality. It also works on pilot small-scale wastewater treatment and disposal systems in rural areas to protect the irrigation and drainage systems from pollution.

The responsibility for water quality and environmental protection is shared with other ministries. The Ministry of State for Environmental Affairs is responsible for the environmental political and governance function. Its Egyptian Environmental Affairs Agency (EEAA) is responsible for the operational function and the implementation of Law 4/1994 for the protection of the environment and its resources including water. Law 4 for the environment includes direct reference to Law 48/1982 for the protection of water resources, which is administered by MWRI. The Ministry of Housing, Utilities and New communities is responsible for the governance and organizational function of planning and investment in the Water Supply & Sanitation sector, while the Holding Company for Water Supply and Sanitation with its subsidiary companies are responsible for the operation and maintenance of the drinking water and sanitation infrastructure.

The hydrological hierarchy dictates a limited mandate for the governorates in the field of water resources management. The governorate level is responsible for physical planning and drinking water supply and sanitation services in coordination with the Ministry of Housing and the Water Supply and Sanitation Companies.

The Land Reclamation Sector of the Ministry of Agriculture and Land Reclamation (MARL) and private sector investors are responsible for the development of the tertiary level (Farm Level) irrigation infrastructure in the new land reclamation areas.

The Ministry of Electricity & Energy is responsible for the governance and organizational function in the electricity sector. The Egyptian Electricity Holding Company is responsible for the operational function and has five member companies involved in generation, one in transmission and nine in distribution and billing of electricity.

The Ministry of Economic Development & the Ministry of Finance has the mandate of prioritising national budget allocation to the different ministries and governorates. The Ministry of Investments promotes private sector investments in the water sector, however the interest of private investors is currently limited to land reclamation initiatives.

The Ministry of Local Development oversees activities at the governorate Level. The Ministry of Foreign Affairs is responsible for the bi- and multilateral relations between Egypt and other countries.

An inter-ministerial committee, assisted by a technical committee, and a secretariat within the MWRI has been formed to oversee the implementation of the National Water Resources Plan (NWRP). On the other hand, a High-Committee on Water has recently been formed and headed by the Prime Minister including Ministers of Water Resources & Irrigation, Foreign Affairs, Internal Affairs & National Security, & Defence. The mandate of the committee is to decide on key political issues related to water.

11.1.12 Sudan

The Ministry of Irrigation and Water Resources is the federal body in Sudan that is responsible for the governance functions for the water sector[6]. The National Council for Water Resources is the high level decision making body for policies and legislation and has representatives of the water related ministries, the state governments and stakeholders in the water sector. There is also a National Coordination Committee for the Blue Nile, which advice the senior MIWR decision makers about the operation of dams in which stakeholders for the water release planning are represented.

[6] The governance function covers both the constitutional and organizational functions.

Table 11.2 Key institutions involved in the water sector of Sudan

Constitutional function	Organisational function	Operational function
Ministry of Irrigation and Water Resources (MIWR)	Ministry of Irrigation and Water Resources (MIWR)	State Departments of Physical planning and water affairs[7]
National Council for Water Resources (NCWR)	Ministry of Agriculture and Natural Resources (MANR)	State Departments of Agriculture and Natural Resources *1
Ministry of Agriculture and Natural Resources (MANR)	State Minister responsible for Physical planning and water affairs	National Water Corporation
Higher Council of Environment and Natural Resources (HCENR)	State Minister responsible for agriculture and natural resources	Sudan National Electricity Corporation
Ministry of Energy and Mining (MEM)		Management Boards of national irrigation schemes
Ministry of Finance and National Economics		Agricultural Corporations
Ministry of Environment and Tourism		Water Users Associations
Ministry of Local Government		
Ministry of Foreign Affairs		

The Nile Waters Directorate and the Dams and Nile Control Directorate are the two directorates that are responsible for managing the Nile water resources of Sudan. The irrigation schemes and the drinking water treatments plants are the main consumptive users of the water, while the hydropower plants are the main non-consumptive water user in Sudan.

The Irrigation Services Directorate is responsible for the management of the four national irrigation schemes (Gezira and Managil, New Halfa, El Suki and Rahad) and the water supply to irrigation schemes that are managed by the State Governments.. The Irrigation Service Directorate supervises the semi-autonomous management boards, which was responsible for the management of the national irrigation schemes.

The National Water Corporation is responsible for the governance and organisational functions in the drinking water sub-sector. The State Drinking Water Corporations, under the authority of the respective state ministers, are responsible for the operational function.

The Sudan Electricity Regulation Authority of the Ministry of Energy and Mining is responsible for the governance function in the electricity sector. The National Electricity Corporation is responsible for the organizational and operational function of the hydropower plants.

The Ministry of Finance and National Economy has the mandate to prioritise the investments proposed by the public-sector organizations in the water sector at federal and state level. The Ministry of Investments promotes private sector investments in the water sector, however their interest currently limited to hydropower plants and small scale irrigation schemes.

The Higher Council for Environment and Natural Resources is the high-level decision making body for policies and legislation on environment and natural resources. The Ministry of Environment and Tourism is responsible for the governance and organisational functions. The HCENR supervises the environmental and social impact assessments of national projects that are proposed by the public and private sectors, including in the water sector.

[7] The ministries and departments at state level dealing with water and irrigation have different names depending on the major activities in the specific state.

The Ministry of Local Government and the Ministry of Foreign Affairs are responsible for respectively the relations in the water sector between the state and federal governments, and for the bi- and multilateral relation in the water sector of the federal government.

11.1.13 Ethiopia

The Ministry of Water Resources is the federal body in Ethiopia that is responsible for the constitutional and organizational function for the water sector. The state governments have jurisdiction over the water resources within their territory but when water passes the boundary of the state it becomes the mandate and jurisdiction of the federal state.

The Ministry of Water Resources is composed of nine technical departments and eight supportive units that mainly focus on the governance and organizational function. Semi-autonomous bodies and the regional water bureaus are mainly responsible for the operational function.

A Technical Committee that is chaired by the head of the Hydrology Department and has representatives of the involved MWR departments and stakeholders, prepares the water release plans of the dams. The Minister and the State Minister of MWR have the final decision about the water release plans.

The Planning and Projects Directorate focuses on the constitutional function in the MIWR. It is responsible for the formulation of the national water policy and strategy, the review of the national irrigation policy and strategy, and the technical planning for water resources development.

Table 11.3 Key institutions involved in the water sector of Ethiopia

Constitutional function	Organisational function	Operational function
Ministry of Water Resources (MWR)	*National Council for Water Resources (NCWR) *MWR technical Departments and supportive units *Water Resources Development Fund *State Bureaus of Physical Planning and Water Resources Development	*State Bureaus of Water Resources Development [8] ˜ Management Boards of national irrigation schemes *Municipality Water Boards *Community-based Organnizations
	(River Basin Authorities)	
Ministry of Agriculture and Rural Development (MARD)	State Bureaus of Agriculture and Rural Development	State Irrigation Development Authority
	Water Harvesting Department MARD	*Water Users Organizations *Agricultural Corporations
Ministry of Energy and Mining (MEM)	Ethiopian Electricity Agency	Ethiopian Electricity and Power Corporation
Ministry of Finance and Economic Development		
Ministry of Environment and Tourism	Environmental Protection Agency	
Ministry of Local Government	Regional Government Authorities	Local Government Authorities
Ministry of Foreign Affairs		

The MWR Boundary and Trans-boundary Department is responsible for undertaking studies and negotiating treaties pertaining the utilization of boundary and trans-boundary water bodies.

[8] Also in Ethiopia the ministries and departments at state level dealing with water and irrigation have different names depending on the major activities in the specific state.

The Hydrology Department is responsible for collecting nation-wide hydrological information, flood forecasting and disseminating this data to public and private sector agencies responsible for the planning and implementation of water resources management.

The Dams and Hydropower Department conducts studies and develops designs for Hydropower projects. It is also responsible for the development of environmental, social and safety guidelines for dams that have to be applies nation wide.

The Irrigation and Drainage Department is responsible for the planning and design of large- and medium scale irrigation schemes on request of the Water Bureaus/ Irrigation Development Authorities and private or water users organizations. The Water Harvesting Department of the Ministry of Agriculture and Rural Development is responsible for WUA legislation development, technical assistance and capacity building of the regional Bureaus of Agriculture and Rural Development. These bureaus are responsible for the technical and institutional components of water management (irrigation extension and WUA) including water harvesting for small-scale irrigation schemes.

The Water Resources Administration and Urban Water Supply and Sanitation Service and the Rural Water Supply and Sanitation Departments are responsible for the constitutional function in water supply and sanitation in respectively the urban and rural environment. The Bureaus of Water resources have an organizational function at state level while the municipality water boards and community-based organizations should become responsible for the operational function respectively in the urban and rural areas.

The MWR Basin Development Study and Water Utilization Control Department is responsible for the development of the River Basin Master Plans, the water resources administration, and the preparation of institutional set-up of River Basin Authorities.

The Ministry of Mines and Energy has the constitutional function for the electricity sector, the Ethiopian Electricity Agency has the regulatory function and the Ethiopian Electricity and Power Corporation has an organizational and operational function. The actual operation of hydropower dams is the responsibility of the Ethiopian Electricity and Power Corporation.

The Ministry of Finance and National Economy has the mandate to prioritise the investments proposed by the public-sector organizations in the water sector at federal and state level. The Ministry promotes private sector investments in the water sector, however their interest currently is limited to hydropower plants and small-scale irrigation schemes.

The Ministry of Environment and Tourism has the constitutional function for environment management. The Environmental Protection Agency is responsible for the preparation of environmental protection policy, laws and directives. It is also in charge of evaluating the environmental and social impacts of economic development projects, like irrigation and hydropower, and supervision of the mitigating measures

The Ministry of Local Government and the Ministry of Foreign Affairs are responsible for respectively the relations in the water sector between the state and federal governments, and for the bi- and multilateral relation in the water sector of the federal government.

11.1.14 Kenya

The responsibility for managing the water resources of the country lies with the Ministry of Water And Irrigation (MW&I). Following the adoption of the National Water Policy in 1999, the ministry embarked on a legal and institutional reform process that aimed for a separation of the constitutional, organizational and operational functions in water resources management and water services provision. The MW&I mandate formed the constitutional function for the water sector.

The Water Resources Management Authority (WRMA) obtained the mandate for the organizational function in water resources management, which covered also the administration of water use rights. The Water Services Regulatory Board (WASREB) obtained the mandate for the organizational function in the provision of water services. Both organizations have national headquarters and seven regional offices that have administrative areas within river basins as their working areas. Two of these regional Water Services Board regions are situated in the Nile Basin: Lake Victoria South and Lake Victoria North. Jointly these two regions are known as the Lake Basin Region, where the Lake Basin Development Authority is responsible for regional development planning under the mandate of the Ministry of Regional Development.

Table 11.4 Key institutions involved in the water sector of Kenya

Constitutional function	Organisational function	Operational function
Ministry of Water and Irrigation (MW&I)	Water Resources Management Authority (WRMA) (national and regional)	Water Resource Users Associations
	Water Services Regulatory Board (national) and Water Service Boards (regional)	Water Service Provider
	Water Services Trust Fund	National Irrigation Board (NIB)
	National Water Appeals Board	
	Catchment Area Advisory Committees (CAAC)	Water Resource Users Associations
Ministry of Agriculture	Kenya Agricultural Research Institute	*Agricultural Companies *Water Users Associations
Ministry of Energy (M0E)	Kenya Power and Lightning Company	Kenya Electricity Generating Company
		Kenya Power and Lightning Company
Ministry of Environment and Natural Resources	National Environmental Management Authority (NEMA)	Lake Victoria Environmental Management Program
Ministry of Regional Development	Lake Basin Development Authority	Private investors

The WRMA regional offices are responsible for water resource management and administration in the river basins. The authorities are responsible for water allocation and apportionment, the monitoring and issuing of licences for the use of surface and ground water. If the Water Services boards want to develop a service provision agreement with a service provider, they need a prior licence from the WRMA to pump surface or groundwater or to discharge wastewater.

The Water Services Boards are responsible for the efficient and economic provision of water and sewerage services within their administrative areas. However, the boards cannot provide these services themselves; they have to enter into services provision agreements with water services providers from the private of voluntary sector.

The National Water Appeal Board (NWAB) is the principal body at national level for resolving disputes about conflicting water resources uses or water use rights. In case the WRMA of the WSRB fail to resolve a dispute between stakeholders in the water sector, the parties can make an appeal to NWAB. The NWAB has a mediating function and its decisions are binding for the disputing parties.

The Water Services Trust Fund (WSTF) is a corporate body with the mandate to provided financial assistance to organizations engaged in the provision of water services to areas without adequate level of services. The funds channels funds of the national government and of international donors towards local level organizations that provide drinking water supply and sanitation services.

The Catchment Area Advisory Committees (CAACs) are established as consultation platform between the WRMA regional offices and the users organizations in specific catchment areas. Through this platform the private and voluntary organizations, which are active in the water and environment sector, participate in decisions concerning water resources conservation, use and apportionment.

The Water Resource Users Associations (WRUA) and the private services providers are responsible for the operational function in water resources management and water service provision at local level. The WRUAs involve in the management of common pool resources, awareness raising and dispute settlement among water users, and catchment conservation measures to improve water quality and quantity.

The National Irrigation Board is placed under the MW&I and it is responsible for the management of six larger irrigation schemes of which three (Ahera, West Kano and Bunyala) are in the Lake Basin Region. These schemes have a total irrigated area of 2.200 has and there are plans to expand the irrigated area in the region.

The Ministry of Agriculture is responsible for agricultural and national food policies, and for research, extension and phyto-sanitary services. The ministry supervises many semi-public organizations that are active in research, extension, primary production marketing and advocacy for the sector in general or specific crops.

The Ministry of Energy is responsible for the constitutional and organizational function in the electricity sector. The Kenya Electricity Generating Company (KENGEN) has as mandate the planning and management of thermal and hydropower plants The Kenya Power and Lighting Company (KPLC) has the transmission, distribution and billing of electricity as its mandate.

The Ministry of Regional Development has the constitutional and organizational function for regional development as its mandate. The Ministry supervises the Lake Basin Development Authority, which has the planning, co-ordination and implementation of development projects in the Lake Victoria basin as its mandate. Water resources planning and management forms a crucial component of regional development planning.

The Ministry of Environment and Natural Resources has the constitutional and organizational function for environment, mining and forestry as its mandate. The Ministry supervises the Lake Victoria Environmental Management Project (LVEMP), the National Environmental Management Authority and the Kenya Forestry Research Institute.

The National Environment Management Authority (NEMA) has been established to supervise the implementation of the National Environmental Management and Coordination Act (EMCA) No. 8 of 1999. The act made it mandatory to conduct environmental impact assessments during the planning of public and private sector economic development projects. NEMA is also responsible for the supervision of the mitigating measures that formed a pre-condition to issuing the letter of no-objection.

11.1.15 Uganda

The constitutional function for managing the water resources and environment in Uganda lies with the Ministry of Water, Lands and Environment (MWLE). The Directorate of Water Development is responsible for organizational function since it coordinates and regulates all water sector activities. The Water Resources Management Department is responsible for water flow and water quality monitoring, and manages water rights and pumping permits.

The Water Policy Committee is a multi-disciplinary and multi-stakeholders committee that performs the constitutional function for the water sector. The committee advises the Minister on national and trans boundary water resources management issues and policies. It is mandated to initiate revisions to legislations and regulations, and to coordinate sector ministry plans and programs affecting water resources.

Table 11.5 Key institutions involved in the water sector of Uganda

Constitutional function	Organisational function	Operational function
Ministry of Water, Lands and Environment (MWLE)	*Water Policy Committee *Directorate of Water Development and Water Resources Management Department (MWLE)	Local government authorities (districts, municipalities and local communities)
	Directorate of Environmental Affairs (DEA)	Local Governmnet authorities
	Lake Victoria Environmental Management Project	*Fisheries Management Committee, *Beach Management Units
	National Environmental Management Authority (NEMA)	
	National Water and Sewerage Corporation (NWSC)	National Water and Sewage Corporation
Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)	Department of Farm Development (Irrigation and Drainage, Soil and Water conservation, Water and Production Sections)	*Water users groups and associations *Agricultural Companies
Ministry of Energy and Minerals Development	Electricity Regulation Authority	Electricity Companies
Ministry of Finance		
Ministry of Local Government	Local Government Authorities	

The National Environmental Management Authority (NEMA) is responsible for the organizational and operational function of environmental management in Uganda. It is responsible for the development of the wastewater discharge regulation, reviews the EIAs, and supervises the mitigating measures of approved public and private sector projects.

The National Water and Sewerage Corporation (NWSC) is an autonomous para-statal entity that is responsible for the delivery of water supply and sewerage services in the 15 large urban centres of Uganda.

Local authorities, which comprise districts, towns, local governments and communities, are responsible for the construction and management of water supply and sanitation facilities outside the large cities. The Municipal councils have the mandate to supervise the management of water supply and sewerage facilities at local level.

The Department of Farm Development (DFD) within the Ministry of Agriculture, Animal Industry and Fishery has the mandate for land reclamation in Uganda. The Department has a Division of Watershed Management that has three water related sections: Irrigation and Drainage, Soil and Water Conservation, ands Water for Agricultural Production. In the past the Government of Uganda used a supply-oriented approach for irrigation and drainage development with the public sector responsible for management. In the early 1990s a farmers' participation in the planning, construction and management was piloted.

The Ministry of Electricity and Minerals Development (MEMD) is responsible for governance functions in the electricity sector. The Electricity Regulatory Authority is responsible for the development and supervision of the regulatory framework for public and private companies that invest in the electricity sector. These companies manage the power generation, transmission and distribution systems.

11.1.16 Tanzania

The responsibility for managing water resources in Tanzania lies with the Ministry of Water (MoW). The Ministry focuses on the constitutional and organizational function of water resources management. The Local Government Authorities obtained the responsibility of the operational function for water resources management from the national and regional administrations. The District Water Engineer Offices, now operating under the directives of the Local Government Authorities, became responsible for the provision of technical advisory services in line with the water resource management directives of the Basin Water Offices that are organised at river basin level.

The National Water Board is the principal advisory body to the Ministry of Water on matters pertaining the utilization of water nationally and the allocation of water rights. The Board has representatives of the water related ministries, the regional secretariats, stakeholders of the private and voluntary sector, and research institutes.

The responsibility for managing the water resources of Tanzania lies with the Ministry of Water (MoW). The Ministry focuses on the constitutional and organizational function of water resources management. Until the 1990s the Ministry of Water and Livestock Development managed the water resources on the basis of administrative regions. The MOW focused on the constitutional and organizational function in line with the National Water Policy of July 2002. The Local Government Authorities obtained the responsibility of the operational function for water resources management from the national and administration. The District Water Engineer Offices, now operating under the directives of the Local Government Authorities, became responsible for the provision of water services and under accordance with the water resource management directives of the Basin Water Offices that are organised at river basin level.

The National Water Board is the principal advisory body to the Ministry of Water on matters pertaining the utilization of water nationally and the allocation of water rights. The Board has representatives of the water related ministries, the regional secretariats, stakeholders of the private and voluntary sector, and research institutes.

Table 11.6 Key institutions involved in the water sector of Tanzania

Constitutional function	Organisational function	Operational function
Ministry of Water Resources (MWR)	*National Water Board (NWB) *Basin Water Offices	*Basin Water Offices *District Water Engineer Offices
	Energy and Water Utilities Regulatory Authority (EWURA)	*Urban Water Supply and Sewage Authorities *Community-based organizations
Ministry of Agriculture, Food Security and Cooperatives (MAFS)		*Zonal Irrigation Engineers Offices *District Agricultural and Livestock Offices
		Irrigators' Associations/ Water Users Associations
Ministry of Natural Resources and Tourisms (MNRT)	*National Environmental Management Council *MNRT Division of Environment	Local Government authorities
Ministry of Energy and Minerals (MEM)	Energy and Water Utilities Regulatory Authority (EWURA) *Tanzania Electricity Supply Comapny	Tanzania Electricity Supply Company
Ministry of Finance		

Constitutional function	Organisational function	Operational function
Ministry of Local Government	Regional Government Authorities	Local Govemrnent Authorities
Ministry of Foreign Affairs		
Lake Victoria Fisheries Organization	Fisheries Management Committee	*Beach Management Units *Fisheries Division Local Government Authority

The Energy and Water Utilities Regulatory Authority (EWURA) was formed in 2001 to regulate electricity supply, water supply and sewerage services. The Municipalities are responsible for water supply and sanitation services in the urban areas. For this purpose Urban Water Supply and Sewerage Authorities have been established that manage the drinking water systems, and the drainage and sewage water treatment systems in the territory of the municipalities. In the rural areas Community-Based Organizations are responsible for the development and management of drinking water supply systems.

The Ministry of Energy and Minerals is responsible for governance functions in the electricity sector. EWURA is responsible for the regulatory function in the electricity sector. The Tanzania Electricity Supply Company is responsible for the organizational and operation functions including the development of hydropower generation and the management of hydropower plants.

The Ministry of Natural Resources and Tourisms is responsible for the governance functions of sustainable management of natural resources. These natural resources cover forestry, wildlife, fisheries and wetlands. The operational function has been delegated to the natural resources related divisions of the Local Government Authorities.

The Division of Environment has the responsibility for the governance functions in relation to environmental management. The Division develops the guidelines for environmental protection and manages trans-boundary environmental management programs. The National Environmental Management Council is responsible for the organizational function of protected areas and for the review of environmental impact assessments and conducting environmental audits.

11.1.17 Rwanda

In Rwanda, the constitutional and organizational functions for water resources management is the mandate of the Ministry of Lands, Environment, Forests, Water and Mines (MINITERE). The Ministry has a small unit, which used to be the Directorate for Water and Sanitation that takes care of the constitutional function. The unit is also responsible for the planning of drinking water supply and sanitary services, however the establishment of the Rwanda Water and Sewerage Corporation in 2008, will limit their mandate to water sector policies and water resources management.

Table 11.7 Key institutions involved in the water sector of Rwanda

Constitutional function	Organisational function	Operational function
Ministry of Lands, Environment, Forests, Water and Mines (MINITERE)	Rwanda Environmental Management Authority (REMA)	*Electrogaz-Rwanda *(Rwanda Water and Sewerage Corporation (RWASCO))
Ministry of Agriculture and Livestock (MINAGRI)		Project Management Units of rural and water resources development projects *Local Water Users Organizations

Constitutional function	Organisational function	Operational function
Ministry of Infrastructure (MININFRA)	Rwanda Utilities Regulatory Agency (RURA)	
	(National Energy Development Agency (NEDA))	(Rwanda Energy Corporation (RECO))
Ministry of Economy and Finance (MINECOFIN)		
Ministry of Health (MINISANTE)		
Ministry of Local Affairs (MINALOC)	Regional Administration	District Administration

MINITERE has established the Rwanda Environment Management Authority (REMA) to supervise that public and private sector institutions take care of environmental protection aspects (respect of standards, rules and regulations, etc.). REMA reviews and approves the EIAs and conducts environmental audits to supervise that mitigating measures are implemented.

The Ministry of Infrastructure (MINIFRA) is responsible for the constitutional functions for public utilities, that cover the energy and water and sanitation services sub sectors. MINIFRA has established the Rwanda Utilities Regulatory Agency that has an organizational function to develop and supervise the regulatory frameworks for public utilities like electricity, water and sanitation, transport and telecommunication.

Electrogaz is a para-statal that is still responsible for both energy and urban water supply. However in 2008 the organization will be split into the Rwanda Water and Sewerage Corporation (RWASCO) and the Rwanda Energy Corporation (RECO). The RWASCO will obtain the operational function for water supply and sanitation services provision and RECO the operational function for electricity generation, transmission and distribution. A National Energy Development Agency (NEDA) will also be created in January 2008 that will become responsible for the organizational function in the energy sector.

The Ministry of Agriculture and Livestock (MINAGRI) is responsible for rational water use in the agricultural sector, water supply for the livestock sector, and the development of the fisheries sector. The water uses in the agricultural sector cover both irrigation and drainage development, and soil erosion protection.

The Ministry of Finance and Economic Planning (MINECOFIN) is responsible for creating a stable macroeconomic environment, foster evidence based planning and performance based budgeting. MINECOFIN has developed an Economic Development and Poverty Reduction Strategy and is considering the basins as basic units for regional development planning. The Ministry has established sectoral working groups in which government organizations, donors, NGOs' and representatives of the private and voluntary sector organizations coordinate their activities.

The Government of Rwanda is implementing an ambitious public sector reform process that aims at a decentralization of operational responsibilities to the lower administrative levels and enhancing the private sector's involvements. The districts are charged with local economic development planning and the coordination of public services delivery.

11.1.18 Burundi

In Burundi, the governance functions for water resources management are shared between the Ministry of Energy and Mines, the Ministry of Agriculture and Livestock, and the Ministry of Land Management, Environment and Tourism. The Ministry of Energy and Mines is responsible for the constitutional and organizational function for water resources management. The Ministry of Agriculture and Livestock is responsible for water uses in the agricultural sector, water supply for the livestock sector, and the development of the fisheries sector. The Ministry of Land

Management, Environment and Tourism is responsible for irrigation and drainage development, and watershed and soil erosion prevention.

The Water Resources Department in the Ministry of Energy and Mines takes care of the constitutional and organizational functions for water resources development. The department supports the National Commission of Water and Energy (NCWE), which main objective is the coordination of the various ministries and organizations involved in water resources management and hydropower generation. The NCWE has a leading role in the development of water legislation and the protection of water and energy resources, and the Geographical Institute of Burundi acts as its secretariate..

The Electricity Department of the DGEE in the Ministry of Energy and Mines is responsible for the constitutional and organizational function for the electricity sector. The electricity departments of the municipalities (REGIDESO) have the operational function for the generation, transmission and distribution in urban environments. The Rural Energy Departments of the provinces (DGHER) have the operational responsibility for the rural areas.

Table 11.8 Key institutions involved in the water sector of Burund i

Constitutional function	Organisational function	Operational function
Ministry of Energy and Mines (MEM)	MEM Water Resources, Electricity, Water, Geology Departments	*REGIDESO Water Department * DGHER Water Department
	MEM Energy Department	*DGHER Electricity Department *REGIDESO Electricity Department
Ministry of Agriculture and Animal Husbandry (MAL)	MAL General Directorates of Planning, Pedology & Soil conservation, Livestock, Fisheries	*MAL Department of Rural Engineering and land patrimony conservation *Water Users Associations *Departments of Fisheries *
Ministry of Land management Environment and Tourism (MINATET)	MLET GD Land Management, Rural Engineering and Land Patrimony Conservation, and Hydrometeorology, Technical, Environmental, Topography and Cartography Departments	
	National Institute for Environment and Conservation	Local stations National Parks
National Commission for Water and Energy (NCWE)	Geographical Institute of Burundi	
Ministry of Planning and Reconstruction		
Ministry of Finance and National Economics		
Ministry of Public Health	Department of Health Promotion, Hygienic and Sanitation	
Ministry of International Cooperation	Non-Governmental Organizations	Community Based Organizations
Ministry of Transport and Communications		Department of Waterways

The Water Resources Department of DGEE in the Ministry of Energy and Mines is responsible for the constitutional and organizational function for water supply and sanitation. The Water Departments of the municipalities (REGIDESO) have the operational function for the production, distribution and billing of water supply and sewerage water treatment in urban environments. The Water Departments of the provinces (DGHER) have the operational responsibility for the rural areas.

The General Directorate of Planning of the Ministry of Agriculture and Animal Husbandry is responsible for the planning of water related projects and programs for the agricultural, livestock and fishery sectors.

The Ministry of Land Management, Environment and Tourism (MINITET) is responsible for the constitutional and organizational functions for environmental protection. The Department of Rural Engineering and Land Patrimony Conservation is responsible for the operational function in irrigation, drainage and soil erosion prevention. The Department of Hydrometeorology and Agro-climatology is responsible for collection, processing and dissemination on meteorological and hydrological data. The Department of Topography and Cartography develops maps that organizations involved in the water sector need for the planning of interventions. The Technical and Environmental Departments of the National Institute for Environment and Conservation is responsible for water and environmental conservation initiatives in the Kivu National Park.

The Department of Waterways of the Ministry of Transport and Communication is responsible for the planning, construction and maintenance of waterways. The Ministry of Public Health has a responsibility related to the prevention of water related diseases and its Department of Health Promotion, Hygienic and Sanitation organized public awareness campaigns..

Beside the public sector organizations that are involved in the water sector of Burundi, there are numerous Non-Governmental Organizations (NGOs) and somet private organizations active in the sector. The NGOs are supporting Community-based Organizations in developing rural water supply, drainage systems for marchland, watershed conservation initiatives. Their projects vary in approach, target population and scale and the Ministry of International Cooperation acts as liaison agency between foreign and local NGOs.

11.1.19 DR Congo

In the Democratic Republic of Congo the mandate for water resources management is the Ministry of Environment, Nature Conservation, Water and Forests,. The Ministry of Energy, the Ministry of Agriculture and Ministry of Transportation and Waterways have responsibilities related to respectively hydropower, irrigation, drinking water and waterways.. The National Action Committee on Water and Sanitation, which operates under the Ministry of Planning, is responsible for policy, strategy and public funding of the water sector. In the territory of DR Congo situated in the Nile Basin, water use for hydropower, environment and water supply are more important than for agriculture.

Table 11.9 Key institutions involved in the water sector of DR Congo

Constitutional function	Organisational function	Operational function
Ministry of Environment, Nature Conservation, Water and Forests (Directorate of Water Resources)	Directorate of Water Resources	*REGIDESO Urban Water and Electricity *National Sanitation Program
	Congolese Institute for Nature Conservation (ICCN-Congo)	*Provincial Directorates *Local stations (parks) *Local Committees for Nature Conservation

Constitutional function	Organisational function	Operational function
Ministry of Planning	National Action Committee on Water and Sanitation (CNAEA)	
Ministry of Energy	National Committee of Energy	*National Electricity Corporation (SNEL) *REGIDESO
Ministry of Agriculture	Directorate of Irrigation	
Ministry of Rural Development	National Rural Waterworks Department (SNHR)	SNHR Provincial Coordination Units
Ministry of Finances		

The Directorate of Water Resources within the Ministry of Environment, Nature Conservation, Water and Forests is responsible for the organizational function of the water sector. The Ministry is responsible for the National Sanitation Program that focuses on improving the environmental services in the urban areas. REGIDESO is the public utility company that is responsible for managing both the electricity distribution as well as the drinking water supply in the urban areas. In the Nile Basin the towns of Bunia, Butembo and Beni, Regideso is responsible for the water supply.

The Ministry of Energy is responsible for the constitutional function related to electric power, covering policy development, authorization and administrative supervision. The National Commission for Energy is a coordination platform of the public, semi-public and private sector that are involved in the electricity sector. The National Electricity Corporation (SNEL) is responsible for the operational function in the electricity generation and transmission and REGIDESO for distribution. The Direction for Rural Engineering of the Ministry of Agriculture and the National Rural Waterworks Department of the Ministry of Rural Development have mandates for respectively land reclamation (irrigation and drainage) and water supply in the rural areas. However, irrigation and drainage development are of minor importance in the Nile Basin.

11.2 River basin and water users organizations

Kenya, Tanzania and Ethiopia have made most progress in developing river basin organizations. Kenya has established regional Water Resources Management Authorities and Water Services Boards for the six main river basins. Tanzania has formed Basin Water Boards and Basin Offices for the nine main river basins. Ethiopia has established one River Basin Authority outside the Nile basin and will established the River Basin Authority for the Blue Nile before 2008. In the other riparian countries the river basin is acknowledged as appropriate management unit for IWRM, however this has not yet resulted in the establishment of water resources management organizations at basin level.

In all riparian states water users groups and associations are promoted for participatory approaches in irrigation management. The rights and obligations of these organizations are in the process of being tested and uniformly defined. However, a legal framework for water users associations and their up scaling from local to supra-local level has not yet been developed with the exception of Sudan. In Sudan the Gezira Act (2005) has been adopted by the Federal Parliament, that provide sweeping responsibilities to water users associations. However, the irrigation officials and the leaders of these organizations have been poorly prepared for the radical institutional changes and therefore the Gezira Act encounters major implementation problems.

11.2.1 Egypt

The current Irrigation and Drainage Law provides a legal framework for the formalization of informal irrigation networks that manage the private tertiary irrigation systems into formal Water Users Associations. The law is in particularly used in the Irrigation Improvement Project (IIP) areas to enhance the users' participation in the planning of the improvements of the privately owned tertiary units and in the land reclamation areas for groups that have to manage their common pool irrigation system jointly.

The MWRI is also piloting joint irrigation management initiatives for the public owned branch, secondary and primary canals through the formation of Federations of WUAs. . In addition, District Water Boards are piloted as a platform where WUA Federations and other stakeholders can collaborate with the lowest MWRI management level. These initiatives have Ministerial Decrees as legal basis and a new Irrigation and Drainage Law is in preparation to create a legal framework for joint irrigation management.

11.2.2 Sudan

The MIWR Dams and Nile Control Directorate has formed two coordination committees for respectively the Blue Nile and Atbara River dams. The committees meet monthly and have representatives of all relevant water related ministries that have an interest in the optimal use of the water resources. The committees consider different water release scenarios of dams for irrigation and hydropower plants and provide recommendations to the federal senior policy makers.

The MIWR Planning Directorate has established five technical offices that provide technical assistance to the Water Resources Departments at state level at river basin level. The technical offices have been established for the White Nile, the Blue Nile, the Upper Nile and two for the Northern Nile. The Technical Offices are responsible forgiving technical support to the planning process between the State Government and for the consultation of the various stakeholders in the planning process.

The Federal Parliament adopted the new Gezira Act in July 2005, which gave sweeping new responsibilities to Water Users Associations and private sector while reducing significantly the role of the public sector. The new Act guarantees free crops choice, transfers title and long-term lease deeds to farmers, privatises 'cost centres' and re focuses the Sudan Gezira Board on agricultural research and technology transfer. The Act has major implications on marketing, credit input supply, water management and maintenance of the irrigation assets. The involved stakeholders in the Gezira Scheme have been poorly prepared for the radical institutional change and there is scepticism about the managerial and financial capacities of the WUAs to take up their new roles and responsibilities.

11.2.3 Ethiopia

The Water Resources Management Policy recognizes that the basin, sub-basin and other hydrologic boundaries as the fundamental planning unit in the water resources management domain. In Ethiopia twelve river basins have been identified of which four are located in the Nile Basin. In the water policy the river basin has been determined as the basic management unit for integrated water resources management. The Basin Development Study and Water Utilization Control Department is undertaking basin master plan studies and they have finalized the studies for seven water basins.

The Awash River Basin Authority has been formed and the Abbay River Basin Authority will be formed before the end of 2007. A new institutional framework is in preparation for the establishment of a semi-autonomous River Basin Authority. Since the river basin covers the territory of more than one state, a reorganization of management function is required. On the one hand a decentralization of management function from the federal water administration is required and on the other hand some management function that are the mandate of the state governments need to be up-scaled to river basin level.

Medium and large-scale irrigation schemes are managed by government enterprises and the farmers themselves management of small-scale irrigation schemes through informal irrigation groups. Small-scale irrigation schemes, which have strong ownership at local level, are considered more efficient than the medium and large-scale schemes. The formation and capacity building of WUA is stated as official policy. However a specific WUA legislative framework, joint management concepts and training modules still need to be developed to create an enabling environment at local level.

11.2.4 Kenya

The Ministry of Regional Development and the Ministry of Water and Irrigation have adopted a river basin approach. Six Regional Offices of the Water Resources Management Authority and six Water Services Boards have been formed for the five river basins in Kenya. In the Nile Basin there are two sub-river basins (Lake Victoria North and Lake Victoria South). The Water Resources Management Authorities are managing the water resources in the basins in an integrated manner and are responsible for matching demand with supply. The river basins are sub-divided into catchment areas for which Catchment Area Advisory Committees are established, that form the interface between the water administration and the private and voluntary sector stakeholders in the water sector.

In Kenya Water Resource Users Associations are formed that differ from the conventional WUAs that are commonly engaged in participatory irrigation management approaches. The Water Resource Users Associations can have representatives of riparian landowners, community water projects, water users as its members and technical advisors form the water administration as observer-members. The main objective of the WRUA is to promote controlled and legal water use activities in an efficient and sustainable manner. The water management practices should recognize the needs of all the communities, livestock, wildlife and environment that all rely on the water source. The WRUA should work towards reducing conflicts in the use of resources and promote conservation measures of the land and water resources.

11.2.5 Uganda

The existing institutional framework in Uganda lacks strong river basin management authorities and catchment boards that manage the water resources in an integrated way. There are lake basin organizations in Uganda that focus more on managing the lakes and its resources than the watersheds that discharge excess water to the lakes.

The current approach to irrigation development and management of water resources is to encourage crops and livestock farmers to form Water Users Associations. These Water User Associations are mandated tot develop and manage water point resources at local level for water supply and for pumped or gravity irrigation purposes.

11.2.6 Tanzania

Major restructuring of water resources planning and management is underway in Tanzania. Basin Water Boards and Basin Offices have been formed for the nine river basins in Tanzania all water resources management is under Basin Water Boards. Presently the basin organizations are developing capacities for monitoring water flows and water quality, assessment, enforcement and pollution control, and the development of integrated water resources management plans.

Irrigators' Associations (IAs) and Irrigators' Groups (IGs), have been formed from the early 1990s onwards. They are expected to become a main actor in the irrigation sector, representing the smallholders' private sector. The rights and obligations of these groups are not yet clearly and uniformly defined through a legal framework.

11.2.7 Rwanda

The newly approved water sector policy considers the basin and sub-basins as the basic units for integrated water management. However, the ministry has limited operation capacities at local level and therefore depends on projects, district governments and NGOs to pilot new initiatives. There are no decentralized structures at basin or catchment areas yet. However, NGOs have initiated some pilots for integrated catchment management in which community based organizations participate. Water users groups are responsible for the management of land reclamation projects at local level. Drainage systems are more important in rural Rwanda than irrigation systems to improve the use of valley bottoms for agricultural purposes.

11.2.8 Burundi

The water sector policy considers the basin and sub-basins as potential units for integrated water management. However, the ministry has limited funds and operation capacities to make its strategies operational.

11.2.9 DR Congo

The water sector policy considers the basin and sub-basins as potential units for integrated water management. However, the ministry has limited funds and operation capacities to make strategies operational.

11.3 Stakeholders Participation

Some riparian countries have created national platforms in which the stakeholders at national level are consulted by the water administration on important policy issues and water resources management decisions. In Sudan the platform is the National Council for Water resources, in Tanzania the National Water Board, and in Uganda the Water Policy Committee. In other riparian states there are standing committees on water and natural resources in the national parliament that are consulted in the review and development of new policies, strategies and legislation.

DR Congo and Burundi have a National Action Committee on Water and Sanitation and the National Commission for the Water and Energy, which have as main objectives to coordinate the various ministries that are directly or indirectly involved in the water sector. In Kenya a Water Appeals Board has been established for resolving water related disputes between different countries in which the stakeholders are involved.

In Kenya, Tanzania and Sudan platforms for stakeholder consultation in water resources management have been formed at sub-river basin level. At these levels conflicting interests in water resources uses have to be resolved during periods of water shortages. The platforms also have a function in creating constituencies for the water resources management decisions. In Ethiopia the River Basin Authorities have a legislative body in which the federal and state governments are represented and the stakeholders from the private and voluntary sector with get an observers status.

In Egypt and Uganda, respectively District Water Boards and District Water and Sanitation Coordination Committees are formed as platforms for the private and voluntary sector organizations to represent their interests through direct consultation with the water managers at district level. In Egypt Federations of WUA are piloted at branch canal and primary canal level. These federations are involved in the decision making for the planning of maintenance activities and the resolution of disputes related to the water distribution between up-and downstream water users.

In all riparian countries the policies aim for cost recovery for the management costs of irrigation and water supply and sanitation services. Recovery of the operation and maintenance costs is becoming a common practice in urban water supply and sewerage water treatment. However, in the poorer segments of the urban society and rural communities face problems with paying the water fees. Therefore mechanisms are developed for improving the cost recovery performance and subsidies for the poorer segments of the urban and rural societies. The private sector is increasingly requested to contribute to the investment costs of irrigation and drainage systems. Experiences show that under the current conditions this is only viable when high-value horticultural crops are cultivated for urban areas and export.

11.3.1 Egypt

Cost recovery for investments in the private owned irrigation and drainage systems is the official MWRI policy for the Irrigation Improvement Project and EPADP. Also the management costs of the lift pumps for the tertiary irrigation systems have to be covered by the beneficiaries. The MWRI is also promoting that water users organization become responsible for the management costs of drainage water reuse stations that have been constructed by the Irrigation directorates. The federation of water users are also starting to contribute to costs of rehabilitating for important water distribution structures.

In some of the new land reclamation areas public funds are used to invest in the main irrigation structures and private investors are requested to invest in the development of the irrigation systems from the water delivery structure in the main irrigation canal.

11.3.2 Sudan

After the liberalization of the economy in 1995, the Government of Sudan withdrew from financing the costs of irrigation services. Farmers were left to pay irrigation schemes to the newly established Irrigation Water Corporations, which were supposed to maintain the canals and deliver water to the farmers. The poor fee collection resulted in the inability of the IWC tot provide services in a sustainable manner. The IWCs were resolved in 2000 and the Federal and State governments became again responsible for the O&M of respectively the large scale and small and medium-scale irrigation schemes. Currently, WUAs are piloted to take management responsibility of the tertiary irrigation system and gradually the organizations will have to share in the management costs of irrigation costs. Private agricultural companies involved in the production of high-value crops already carry the investment and management costs of their private irrigation systems.

11.3.3 Ethiopia

The State Governments determine the contributions of the water users to water infrastructure development. The irrigation authorities have financial autonomy over their approved budget.

Neither cost recovery nor irrigation charges have been considered in irrigation development. However Community Based Organizations are contributing to the maintenance costs of small-scale irrigation systems through free labour.

A Water Resources Development Fund (WRDF) has been established recently within the Ministry of Water Resource to serve as a public intermediary dedicated to supporting public and community-based organizations in the financing the development costs of water supply, sanitation and irrigation systems. The fund provides long-term loans to groups that meet established criteria of which a sound O&M cost recovery mechanism is essential.

11.3.4 Kenya

The management costs of drinking water treatment and distribution have to be covered by the beneficiaries. The Water Services Boards determine the water fees that the service providers can charge. However the service providers have problems to reach the break-even point, in particularly when water treatment and distribution are expensive because of chemical and pumping costs.

The irrigation development is currently led by the private sector and by smallholder irrigation schemes. The private sector is investing in irrigation development in areas close to urban centres for local vegetable and high value horticultural crops for the export market. They cover both the investment and the management cost of the irrigation systems. The smallholder irrigation schemes situated in the arid and semi-arid lands receive grants from donors and the small holders communities contribute unskilled labour and local construction materials. The National Irrigation Board is facing problems in organizing the water users into WUAs and convincing the rice water users that they have to carry a larger share of the management costs.

11.3.5 Uganda

The costs of drinking water production and distribution have to be covered by the water users themselves in Uganda. Therefore the Municipality Councils fix the water fees that the beneficiaries have to pay in the urban areas and the Community Based Organizations decide about the fees for the systems that they manage in the rural areas. Irrigation promotion is central to the current government policy, where strategic interventions on export promotion of high value crops is emphasized. The producers of these crops can afford to pay the investment and management costs of pumped irrigation systems. However, agricultural subsidies and low interest rates still are needed to enable private farmers or associations to invest in modern technologies.

11.3.6 Tanzania

The costs of drinking water production and distribution have to be covered by the water users themselves. Therefore the Urban Water and Sewage Authorities fix the water fees in accordance with the EWURA guidelines and regulations that the beneficiaries have to pay in the urban areas and the Community Based Organizations decide about the fees for the systems that they manage in the rural areas. The Irrigator groups and the water users have to pay for the operation and maintenance costs of their system. However the government has the policy that lower water and irrigation fees are charge to the poorer strata of society. For this purpose special water fees are fixed for poorer households and subsistence farmers. For the investment costs grants are made available thought the national budget and increasingly through the local government authorities.

11.3.7 Rwanda

Electrogaz is a para-statal organization that provides water supply services on cost basis in the urban areas. The beneficiaries have to cover the management costs. There have been attempts to give management contracts for major drinking water plants to international private sector companies. These pilots have been stopped earlier than planned.

In the rural areas community based organizations have managed water supply systems, however they face financial problems to collect the water fees. The new official policy is that the management of all piped drinking water supply systems will be subcontracted to the private sector and that community based organizations will manage wells and other systems that use simple technologies.

11.3.8 Burundi and DR Congo

Para-statal organizations that are responsible for the management of drinking water and sanitation services have to cover the management costs through water fees that are paid by the users. Cost recovery mechanisms are functioning in the urban setting but not in the rural areas.

11.4 Innovative Pilot Projects

In the riparian state innovative institutional and technical pilot projects are implemented in the fields of IWRM, and soil and nature conservation. The Nile Basin Initiative is piloting a number of innovative pilot projects in the field of regional power trade, environmental protection, and fishery management.

The institutional reform processes in IWRM focus mainly on the testing of public-private partnerships at local and supra-local level. This requires that the lowest administrative levels of the water agency create capacities for applying a participatory approach. It also requires that new concepts for the sharing of management responsibilities of public-owned irrigation, drainage and drinking water supply systems be tested. These pilots are expected to result in the creation of a supportive legal and institutional environment for participatory management and ultimately in the transfer of management responsibilities to water users and community-based organizations.

Water rights are becoming increasingly important to deal with water shortages, which easily result in conflicts between the head and tail end water users in irrigation systems. Effective demand management systems need to be developed in which individual water users adjust their cropping plans to the available water resources. In Sudan and Egypt pilots project are initiated in which the water administration and the leaders of water users organization agree in advance about the water allocation to branch or primary canals and the water users organizations try to develop social mechanisms for a fair distribution of the water including its shortages among their members.

For watershed conservation innovative institutional project are implemented for community and agro-forestry in Ethiopia, Sudan Kenya, Tanzania and Rwanda. In community forestry projects the land tenure relations of common pool resources are clarified in community-based organizations to create incentives for investments for individual farmers. In agro-forestry projects sustainable production systems are developed that are environmentally friendly and require low external inputs. Soil and water conservation techniques form important components of these agro-forestry pilot projects.

The innovative technical projects focus on the development of water saving technologies (drip and sprinkler irrigation), and the development of low cost systems for water supply and sanitation services (eco-sanitation).

In DR Congo and Rwanda the nature conservation agencies has signed trans-boundary collaboration agreements for the Gorilla Conservation Program. The Virunga National Park occupies a significant part of the Congolese Nile Basin and a minor part of Rwanda, and constitutes a significant potential for tourism in the region. Currently the park is exposed to population pressure and civil unrest in the region.

12 Trans-boundary water management

12.1 Trans-boundary projects (regional, sub-regional)

The Nile Basin Initiative (NBI) is a transboundary regional partnership project among the ten Nile Basin riparian countries. It provides a forum for cooperative development of the river's water resources, including sharing substantial economic benefits and promoting regional peace and security. The NBI was formally established in 1999 and is guided by a shared vision to achieve "sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources". The NBI is governed by a Council of Ministers of Water Affairs of the Nile Basin States (Nile-COM). The NBI Secretariat (Nile-SEC) is located in Entebbe, Uganda.

NBI members developed the Strategic Action Program (SAP) to translate their overall vision into tangible activities and projects. The SAP is composed of: (i) the Shared Vision Program (SVP) focusing on basin-wide projects to create an enabling environment on the ground, and (ii) the NBI Investment Programs consisting of sub-regional Subsidiary Action Programs, focusing on sub-basin projects to deliver development projects involving two or more countries.

12.1.1 Shared Vision Program (SVP)

SVP is designed to: (i) build trust across the basin, (ii) build capacity within the countries, and (iii) create an enabling environment for implementing development projects. SVP projects foster an integrated and comprehensive approach to water resources development and management, and serve as catalysts for broader socioeconomic development, including poverty reduction, economic growth, and environmental protection. SVP presently has a coordinated program of eight projects:

1. Applied Training
2. Confidence-Building and Stakeholder Involvement
3. Efficient Water Use for Agriculture
4. Nile Transboundary Environment Action
5. Regional Power Trade
6. Shared Vision Projects Coordination
7. Socio-economic Development and Benefits Sharing
8. Water Resources Planning and Management

12.1.2 NBI Subsidiary and Investment Programs

- Eastern Nile Subsidiary Action Program

- Irrigation and Drainage Project
- Eastern Nile Planning Model Project (ENPM)

  To address the acute need for a mechanism to screen, rank, and integrate sectoral interests and/or projects, a key component of the ENSAP program is the ENPM Project. ENPM is designed to identify, develop, and implement the necessary water resources planning models and data management systems to effectively analyze alternative development scenarios in the sub-region. The modeling tools to be developed will be used as a part of the overall planning process for future investment in the EN region, providing decision-makers in all three ENSAP countries with the water resources data and information needed to determine how best to develop, utilize, and conserve the Eastern Nile water resources. The Project will also address institutional and human capacity strengthening at the regional and national levels, as well as the most appropriate and efficient institutional arrangements to ensure the technical and financial sustainability of the model. The ENPM Project contains three major components: (i) the modeling system, (ii) the information management system (IMS), and (iii) institutional and human capacity strengthening.

- Watershed Management Project
- Ethiopia-Sudan Transmission Interconnection Project
- Flood Preparedness and Early Warning Project
- Baro-Akobo Multi-Purpose Water Resources Development
- Eastern Nile Power Trade Investment Program Study
- Joint Multi-Purpose Program

  As cooperation among the Nile countries has grown, the three Eastern Nile (EN) countries (Ethiopia, Sudan, Egypt) are now beginning to address the more complex work of transboundary challenges and capturing the shared opportunities afforded by 'three countries, one system." A major focus of ENSAP is to identify and develop cooperative projects that provide visible results and shared benefits. ENSAP believes that real benefits are most likely to be found in the bundling of sectorally focused projects into integrated, multi-purpose project(s). In February 2005, the EN countries agreed to launch JMP, which involves more complex, regional, large-scale, joint win-win projects. The overall objective of JMP is to provide technical assistance and support ENTRO to facilitate the first phase of a major program of joint multipurpose development in the Eastern Nile. To this end, JMP has three components: (i) develop a JMP consultation and planning framework, (ii) develop JMP information and options, and (iii) assist in institutional strengthening and development. ENTRO is facilitating the launch of the JMP and will pursue activities to assist in the rational selection of a first JMP project. ENTRO has identified a number of activities and assessments that will help select a first, and subsequent, joint multipurpose projects.

- Nile Equatorial Lakes Subsidiary Action Program
  - Coordination Unit for Equatorial Lakes Projects

- Integrated Water Resources Management in River Basins
  - Mara River Basin Project Transboundary IWRM Project (Kenya and Tanzania)
  - Kagera River Basin Transboundary IWRM Project (Burundi/Rwanda/Uganda/Tanzania)
  - Sio-Malaba-Malakisi Catchments Transboundary IWRM Project (Kenya and Uganda)
- Water and Agriculture Project
- Kagera Water hyacinth Abatement Project
- Environmental, Social, Strategic and Sectoral Assessment of Energy Generation Alternatives in the Equatorial Lakes countries
- Lakes Edward and Albert Fisheries Pilot Project (Uganda/DRC)
- Lake Victoria Environmental Management Project II (Burundi/Rwanda)
- Regional Rusumo Falls Hydropower and Multipurpose Project (Rwanda/Burundi/Tanzania)
- Regional Interconnection Project (Rwanda/Burundi/Kenya/Tanzania/DRC)

Other joint government & private sector development projects between riparian countries of the Nile basin include:

- Joint operation and Management of the Owens Dam (Uganda & Egypt)
- Joint operation and Management of the High Aswan Dam (Sudan & Egpt)
- Joint Abatement of the Hyacinth in Lake Kyoga (Uganda & Egypt)
- Joint Groundwater Development Project for Drinking Purposes in Kenya (Kenya & Egypt)
- Joint Groundwater Development Project for Drinking Purposes in Uganda (Uganda & Egypt)
- Joint Groundwater Development Project for Drinking Purposes in Ethiopia (Ethiopia & Egypt)
- Joint Modern Irrgation Technology Development in Ethiopia (Ethiopia & Egypt)
- Joint Modern Irrigation Technology Develeopmetn in Uganda (Uganda & Egypt)
- Joint Lake Tanganyika Biodiversity Convservation Project (Brundi, DR Congo, Zambia)

Other key national Nile-related development projects include by country the following:
For Egypt (Elwan, 2007):

- Planned Hydropower Plants on Nile Barrages
  - Nagaa Hammadi Barrage
  - Asyut Barrage

- Others under assessment

- Other Potential Mini-Hydropower Installations
- Irrigation Development Projects
    - South Egypt Development Project (Toshka)
    - West Delta Supplemental & Irigation Improvement Project
    - North Sinai Irrigation & Drainage Reuse Development Project

12.2 Trans-boundary treaties and agreements

There have been several colonial and post-colonial bi-lateral and multi-lateral transboundary treaties and agreements related to the use and management of the waters of the Nile Basin. The following table provides a list of these treaties and agreements.

Table 12.1 Trans-boundary treaties in Nile Basin

Date	Treaty basin	Signatories	Treaty Name
August 5, 1994	Lake Victoria	Kenya, Tanzania, Uganda	Agreement to initiate program to strengthen regional coordination in management of resources of Lake Victoria
July 1,1993	Nile	Egypt, Ethiopia	Framework for general co-operation between the Arab republic of Egypt and Ethiopia
May 18,1981	Kagera	Burundi, Rwanda, Tanzania, Uganda	Accession of Uganda to the agreement for pertaining to the creation of the organization for the management and development of the Kagera river basin
August 24,1977	Kagera	Burundi, Rwanda, Tanzania, Uganda	Agreement for the establishment of the organization for the management and development of the Kagera river basin
November 8, 1995	Nile	Sudan, Egypt	Agreement between Egypt and Sudan the government of the united Arab Republic and the government of Sudan
July 16,1952	Nile	Egypt, Great Britain and Northern Ireland	Exchange of notes constituting an agreement between the government of the United Kingdom of Great Britain and Northern Ireland and the government of Egypt regarding the construction of the Owner Falls dam in Uganda
January 19,1950	Nile	Egypt, Great Britain on behalf of Uganda	Exchange of notes constituting an agreement between the government of the united Kingdom of Great Britain and Northern Ireland on behalf of the government of Uganda and the government Egypt regarding cooperation in meteorological and hydrological surveys in certain area of the Nile basin
December 5 1949	Nile	Egypt, Great Britain on behalf of	Exchange of notes constituting an agreement between the government of the United Kingdom of Great Britain and Northern Ireland and government of Egypt regarding the construction of

Date	Treaty basin	Signatories	Treaty Name
		Uganda	the Owen Falls dam, Uganda
May 31, 1949	Nile	Egypt, Great Britain	Exchange of notes constituting an agreement between the government of the United Kingdom of Great Britain and Northern Ireland and the government of Egypt regarding the construction of the owner Falls dam, Uganda
December 7,1946	Nile	Egypt, Great Britain	Exchange of notes constituting an agreement between the government of the united Kingdom of Great Britain and Northern Ireland and Egypt regarding the utilization of profits from the 1940 British government cotton buying commission to finance schemes for village water supplies
November 22,1934		Belgium; Great Britain	Agreement between the United Kingdom and Belgium regarding water rights on the boundary between Tanganyika and Ruanda - Urundi
May 7,1929	Nile	Egypt; Great Britain	Exchange of notes between his Majesty's government in the United Kingdom and the Egyptian government in regard to the use of the waters of the river Nile for irrigation purposes
December 20, 1925	Lake Tana	Great Britain, Italy	Exchange of notes between United Kingdom and Italy respecting concessions for a barrage at Lake Tana and a railway across Abyssinia from Eritrea to Italian Somaliland
December 13, 1906	Nile	France, Great Britain, Italy	Agreement between Great Britain, France and Italy respecting Abyssinia
May 9,1906	Nile	DR Congo, Great Britain	Agreement between Great Britain and the independent state of the DR Congo, modifying the agreement signed at Brussels 12 May 1894 , relating to the spheres of influence of Great Britain and the Independent State of the DR Congo in East and Central Africa
May15, 1902	Nile	Ethiopia, Great Britain	Treaties between Great Britain and Ethiopia, relative to the frontiers between Anglo- Egyptian Sudan, Ethiopia, and Eritrea
March 18, 1902	Nile	Ethiopia, Great Britain	Exchange of notes between Great Britain and Ethiopia
April 15, 1891	Nile	Great Britain, Italy	Protocol between Great Britain and Italy for the demarcation of their respective spheres of influence in Eastern Africa

Source: UNEP (2002), Atlas of International Freshwater Agreements

There are two other on-going multi-lateral agreements being negotiated by the Nile basin countries which are of major importance to the NBI-DSS. These are:

- Agreement on the Nile River Basin Cooperative Framework; and
- Protocol for Data Sharing.

13 Assessment of Human and Institutional Capacities

13.1 Existing human and institutional capabilities

It is to be noted, that an in-depth study on existing human and institutional capacities in DSS for each country could not be undertaken at the inception period because of time constraints and this will be done by the Consultant in the next phase.

In general the Nile Basin experience in modeling Decision Support Systems and/or supporting models is limited. Many existing models within the region appear to be dealt with as “black boxes”, with some regional staff able to operate the models, but lacking the knowledge and experience to maintain and upgrade the models after donor projects and funding have ended. However a few Nile Basin countries capacity to model and operate models exist but face several challenges of sustainability and continuous knowledge transfer and upgrade. The need to raise human and institutional capacities in data collection, national and regional monitoring in combination with a data exchange protocol are considered as crucial issues for a successful design and operation of a basin-wide DSS systems.

13.1.1 Egypt

In Egypt, and since its establishment in 1991, the Nile Forecast Center at the Ministry of Water Resources & Irrigation, has developed the following institutional and human capacity:

- Development of the NFS and procurement, maintenance, and improvement of the hardware required to run the system including the transportation of the NFS from IBM-RISC workstations (that were expensive to maintain) to personal computers available in the local market and easy to maintain.
- Training of personnel from different Nile Basin countries to foster cooperation between the riparian countries and show the experience of Egypt in carrying out monitoring and forecasting activities.
- Raising the awareness of MWRI engineers and the public about the flood hazard via training courses for MWRI engineers and via a weekly broadcast during the flood season on Nile News Channel (5 years in a row) to inform the public about the situation.
- Improving the technologies used to do the forecasts through:
- Development and improvement of rainfall estimation techniques
- Utilizing the output of weather predication models (ETA) to forecast rainfall and other meteorological variables over the Nile basin
- Continuous update and calibration of existing hydrological models
- Continuous update of the Nile Basin Hydro-meteorological Information System
- Further Development of the HAD-DSS to include the Toshka Project and the suggested enhancements to the Toshka spillway
- Development of the Statistical Downscaling Model (SDM) to enable the use of Global Circulation Models (GCMs) outputs to study the impacts of climate change on the Nile basin and its flood regime.
- Capacity building via continuous training and recruitment of engineers, meteorologists, and computer engineers to help operate and maintain the NFC using local resources

- Introducing new tools (e.g. SOBEK and RIBASIM) to study the effects of higher Nile discharges on the land resources especially in the low lying Delta to assess the flooding risks - RIBASIM Interface)
- Development of a Strategy Assessment Tool (SAT) to assess the pros and cons of different operation strategies of the HAD using multi-criteria indicators covering different technical, management, and socio-economic impacts of probable floods and droughts

13.1.2 Burundi

Only very few individuals understand the modeling technology, not only in the NBI-DSS context, but also in other technical fields. The staff of the different water-related institutions has expressed the need for training courses in various fields relevant for the DSS so that these institutions will be actively involved during the DSS development.

13.1.3 Kenya

Although some models have been use for research and training, the survey made did not come across any operational use of these models. In most cases the models were used for research and training with the exception being LVEMP I which used the NAM model to fill gaps in runoff data.

In the area of water resources there exists a wealth of opportunities and needs for operational uses of hydrological and water resources management models. A case here is the use of models to forecast runoff to serve as a floods early warning tool. Some of the models (NAM, GeoSFM and SWAT) have been calibrated and validated for the Lake Basin catchments and can thus be used for operational purpose. Some preliminary work in the use of models for flow forecasting is currently going for the Nzoia River under the Nzoia Community Driven Development Project. It is the hope of the project that an operational model will eventually be selected for flood early warning.

The model/tool users in Kenya are few and scattered in various public institutions such as universities, research and utility organizations. Even though a few do collaborate there exists no network or professional associations which links them up. This means that valuable knowledge and experience is not shared and duplication is common. Training on the existing models to address the concern of each institution will also improve the capacity of model users and widen their vision on the area of modeling..

13.1.4 Tanzania

The use of water resources planning and management tools in Tanzania is still limited to simple tools which include creation of data bases in Microsoft Access, Spreadsheets (excel) and Hydata software. Excel and Hydata software are also used for data processing. Map making and processing software are in use at the Ministry of Water headquarters and at about 3 basins out of 9. Use of sophisticated models is largely confined to academic and research institutions which are not involved in water management. The Basin Water Offices which are in principal the nucleus of water resources management and planning at basin levels have not seriously embarked on the use of sophisticated models in their routine activities mainly due to lack of capacity and resources. The Water Sector Development Program (WSDP), due to start in the second half of 2007, is expected to build capacity both human and necessary financial resources. Despite the WSDP strategies the development of the Nile Basin DSS needs to concomitantly ensure that capacity in the use of the resulting DSS is build to a good number of relevant personnel and becomes widespread as possible. This is one of the key ways to ensure the sustainability of the DSS real application and the envisaged outcomes in the long term particularly in countries where modeling practice and use of model results in water resources management are still at the infancy stages.

Lack of sufficient capacity in aspects of water resources management particularly in connection to the use of models is another area of concern. The WSDP has a component directly under the Ministry to deal with institutional strengthening and capacity building. The component should target more at building capacity in water resources management and planning particularly on the use and development of models. The Water Resources Planning and Management Project of NBI can also put more resources in building capacity. This can be achieved through training to Basin Water Offices experts on different types of water resources models with potential contribution to the works of the concerned offices.

13.1.5 Uganda

Use of decision support and management tools is still in its infant stages and it is imperative that it is encouraged to grow. It is not possible to identify gaps as the practice is practically non existent. There proven techniques need to be introduced, trained and streamlined in day to day activities at the national level.

13.1.6 Sudan

For Sudan strengthening existing key stations and automatic gate recording equipment as well as training for managing new equipment is a priority. The Ministry ofIrrigation and Water Resources needs to convince the top management of the Ministry of Finance that data collection at the 52 key stations is crucial for modeling the Nile River in Sudan. Currently the data collection at the 17 key stations heavily depends on the Egyptian counterpart organization. The NBI needs to consider developing a crash program for strengthening the monitoring of water levels and flow for all key stations for Nile River modeling and achieving uniform data quality. Some funding from NBI for training and piloting modern equipment will make it easier to obtain national counterpart budget from Ministry of Finance.

13.1.7 Specific knowledge/skills, instruments and incentives related to decision making

Text text text Text text text Text text text Text text text Text text text Text text text Text text text Text text text knowledge/skills, instruments and incentives related to structured decision making, environmental and social impacts assessment, modeling and scenario definition/analysis, water resources information systemsText text text Text text text Text text text Text text text Text text text Text text text Text text text

13.2 Potential areas for improvement

This project with its special focus on the participatory approach creates a lot of momentum; namely with the National Consultations in the Inception Phase, National and Sub-regional Stakeholder Consultations as well as National and Sub-regional Training and Awareness Creation Workshops in the Analysis Phase. The more interest has been created among national and regional stakeholders the more it is important that stakeholder interactions are continued also after this project. Otherwise the risk of loosing the created sense of ownership is high.

Right after the lifespan of this project, communication expectations and training needs should be followed-up and managed. Because national and sub-regional expectations, needs and constrains differ, a mix of interventions consisting of e.g. continuing consultations (county visits), joint workshops, newsletter services, tailor made trainings (seminars and workshops with physical presence as well as facilitation of knowledge development with e-learning tools).

Given

- the huge needs for institutional and capacity building for making the potential and limitations of DSS known as well as operationizing the future DSS for the Nile basin;
- the limitations in simultaniusely working with DSS developers, users, data proviers, and other stakeholders from all riparian countries, regional an sub-regional bodies

it is recommended to continue with a very cost efficient training and awrness creation activity such like e-Learning.

13.3 e-Learning description and advantages

In addition to standard qualification methods, in recent years so-called e-Learning solutions have established themselves as an efficient alternative. e-Learning has proven itself wherever confirmable knowledge is to be transmitted. Skills and expertise that was in former time communicated partially in theory and practically, can be well complemented through e-Learning. The basic contents are either learned using CBT (computer based training with CD-ROM without an Internet connection) or WBT (web-based training of learning contents over a learning platform).

Some advantages of e-learning or blended learning:

- Reduction of travel to classroom sessions
- Reduction of absence during work time
- Reduction of trainer costs
- Reduction of accommodation costs
- Knowledge accessible at any time, according to need („learning on demand")
- Individual learning pace possible
- Monitoring of theoretical knowledge possible
- Improvement of knowledge transfer and knowledge multiplication

13.4 Blended Learning

e-Learning blended with traditional trainings can be an efficient approach. Among others, one variation of blended learning is the use of virtual learning environments for supporting classroom learning. This means that participants receive a user account for a learning platform at the same time they are attending one or more seminars, which can be used to communicate with other learners and tutors and also to carry out tasks related to the contents. In a situation like in the case of the Nile basin, where trainees/representatives/stakeholders from different countries should become acquainted with the same knowledge, this can be an efficient approach for knowledge transfer.

The wide variety of possible implementation scenarios exist and imaginable are all of the combination options, namely sustained changes in behavior to affect the transfer of knowledge so as to become part of the participant's practical experience.

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