The Past and the Future of Flood Management in the Eastern Nile Basin

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Abstract

Since the dawn of human civilization, water related extreme events as floods and droughts have always been a great concern. The Nile River, with its very special nature, fed by rains on the mountains of equatorial Africa and Ethiopian highlands, forced its people all through the years to face great challenges to survive in spite of the periods of abundant floods and severe droughts. To overcome damages caused by floods, people of the Nile have done great efforts, some of them on the country level, some others on the regional one. This study will have on overview on the Eastern Nile Basin (Ethiopia, Egypt and Sudan), its hydrology, climate and the damages caused by floods in this region. The study will also conduct an analysis of previous efforts exerted in the field of flood mitigation and management and the gaps that need to be fulfilled in order to achieve an effective and reliable flood mitigation and management system. The role of Flood Preparedness and Early warring (FPEW) project, one of the Nile Basin Initiative (NBI) projects, will be presented as one of the most recent and promising activities tackling this important issue.

Introduction:

Ancient Egyptians mentioned in their historical texts and on the walls of their temples the very first flood mitigation and management concepts. They even went to personalize the Nile and sacrificed every year, during the flood period, the most beautiful girl as a wife to calm his anger. As Nile water was the only source of life for Egyptian due to the aridity of the climate and the scarcity of rains, they always had the leadership in flood management. The need for Nile water forced the Egyptian to establish one of the first irrigation networks in the world. As fresh water is becoming increasingly scarce in many places and times, water use has risen considerably in the past hundred years twice as fast as the population growth, and water demands for food production, hygiene and human well being continue to grow fast, societies are increasingly vulnerable to droughts and water deficits. On the other hand, economic development of flood- prone areas is a driver increasing flood hazard. Human pressure and shortage of land cause encroachment into flood plains especially by informal settlements and endangered zones around big Cities. There is also an over reliance on the safety provided by flood control works while observations confirm that atmospheric moisture is increasing in many places of our warming planet. Thus, the potential for intensive precipitation and likewise flood is also increasing (Kundzewicz et Al, 2001). Measures therefore have to be taken to face the present and future challenges in the light of the current and expected circumstances in the Nile Basin.

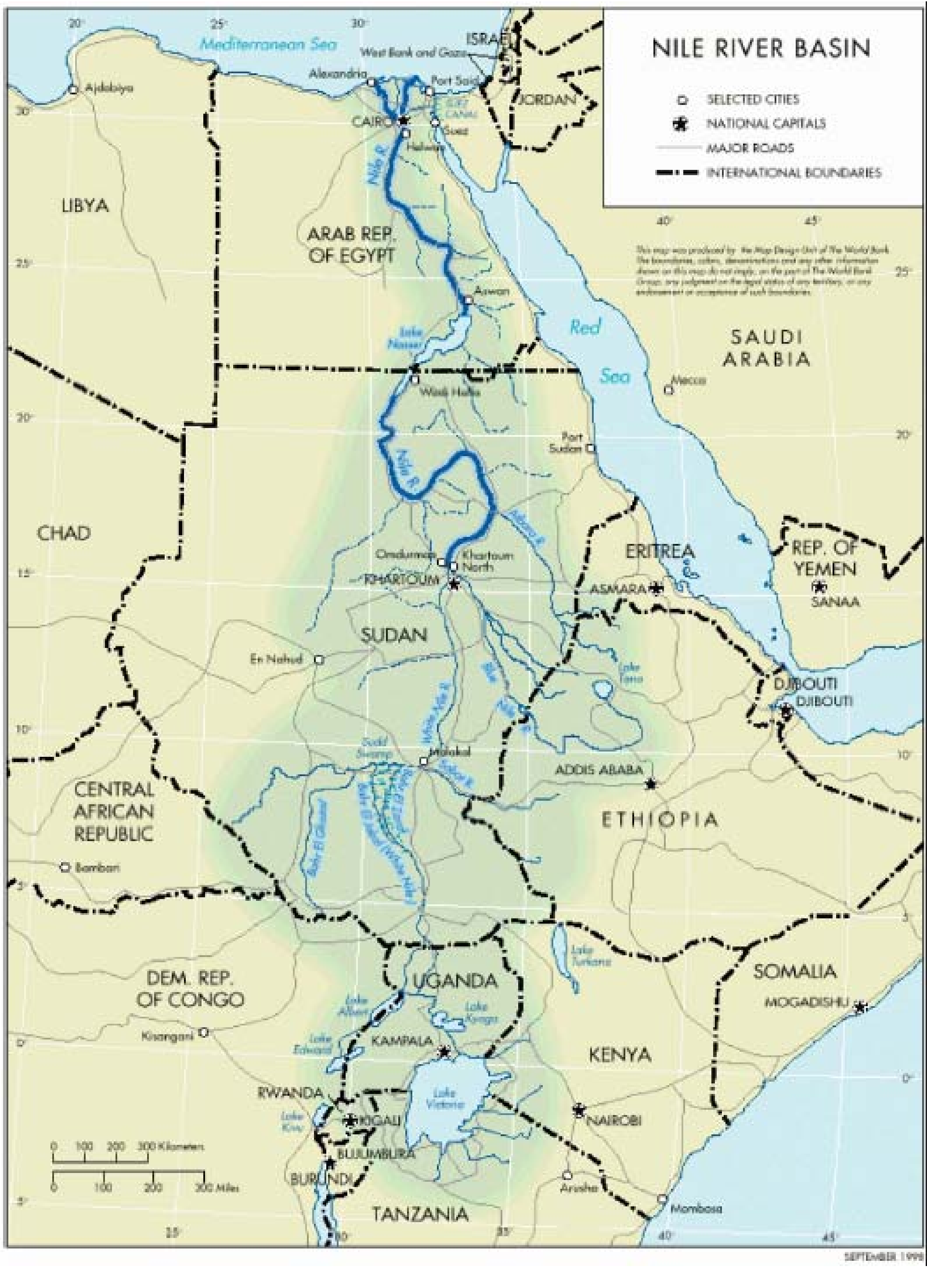

Figure (1) Eastern Nile Region

Regional Background

The countries of the Eastern Nile Region are Egypt, the Sudan and Ethiopia. Main rivers of the Eastern Nile region rise in the Ethiopian Highlands in the western half of Ethiopia and drain generally westerly or north-westerly into the Sudan where the White Nile and the Main Nile drain generally north, and then the Nile flows further north through Egypt to the Mediterranean Sea.

Ethiopia and Sudan experience tropical or sub-tropical climates, with rainfall seasonally biased and most rain falling in the summer months (June to August). Temperatures and annual rainfall depths vary widely, depending on elevation. Parts of the Ethiopian highlands receive average annual rainfall exceeding 2000 mm, while in far northern Sudan and Upper Egypt there is very little rain at all.

Ethiopia:

Ethiopia covers a land area of 1.133 million km^2, of which just over 358 000 km^2 is located in the Eastern Nile river basin. The population of Ethiopia is approximately 70 million and 85% of the national population relies on smallholder subsistence agriculture. In the Tekeze and Abbay sub-basins impacts of flooding are generally minor because most of the population lives on elevated plateaus and not in the deep river valleys. Sporadic flash flooding has been noted in several areas. The main exception is around Lake Tana, particularly where flat plains adjoin the lake. The lowlands of the Baro-Akobo sub-basin are also partially inundated by floodwaters every year.

Sudan:

Sudan is the largest country in Africa in terms of the area of its territory – approximately 2.5 million km^2. The population of the Sudan is approximately 38 million, of which approximately 6 million reside in greater Khartoum at the confluence of the Blue and White Niles. The annual flood from the Blue Nile (Abbay in Ethiopia) replenishes soil moisture and fertility, and recharges groundwater, so is the mainstay of agriculture in much of the country. Hundreds of villages line the banks of the Blue Nile and Main Nile, and because of their proximity to the river banks are adversely affected in years of above average floods. In large floods, lower-lying riparian land in Khartoum may be inundated, and the city of Dongola is at frequent risk from floods.

Egypt:

The land area of Egypt is just under 1 million km^2. The population of Egypt is currently about 75 million, most of who reside along the narrow strip of the Nile River valley or around the river delta. The High Aswan Dam (HAD) was completed on the River Nile in upper Egypt in 1970, and generation of hydropower and regulation of water for irrigation by HAD has become a mainstay of the Egyptian economy. While HAD has had a major mitigation effect on downstream flooding, a series of high flood years in 1998 to 2001 proved that flood risk management is still on the agenda for the government of Egypt.

Geography of the Eastern Nile Region:

The Eastern Nile Basin lies between latitudes 7º N and 31º N. The highlands of Ethiopia are folded and fractured crystalline rocks capped by sedimentary limestone and sandstone, and by thick layers of volcanic lava. Elevations in the Ethiopian part of the river basin exceed 4 000 m in places and there are large areas exceeding 2 000 m. Most of the population lives on the elevated cooler plateaus above the steep river valleys where the soils are more fertile. Soil erosion is a major problem, accelerated by deforestation, overgrazing and poor land management. A key geographical feature in Ethiopia is Lake Tana, created by past volcanic activity, at a mean elevation of 1786.8 m ASL. Although shallow, the lake provides a degree of natural regulation of floods and captures sediment; however it regulates only a small fraction of the river basin in Ethiopia. The outlet of the Abbay River (or Blue Nile) from Lake Tana is located at the city of Bahir Dar, and approximately 32 km downstream the river plunges over the Blue Nile Falls (Tiss Issat). After entering the Sudan, the rivers flowing from Ethiopia traverse much flatter terrain at relatively low elevations, and longitudinal river bed slopes reduce dramatically.
The average slope of the Abbay River between Lake Tana and the border is 1.6 m/km, but over the 735 km from the border to Khartoum the average slope of the Blue Nile is only 0.15 m/km. The catchment area of the Blue Nile to Khartoum is 324 530 km2. The Blue Nile joins the White Nile at Khartoum, the capital of the Sudan. The White Nile flows north from the Equatorial Lakes region to the south, but despite its very large catchment area, seasonal floods from this region are very effectively mitigated, first by the Equatorial Lakes including Lake Victoria and other very large lakes, and second by the extensive marshes of the great Sudd in southern Sudan. Downstream of Khartoum, the joint waters of the Blue Nile and White Nile form the Nile, or Main Nile, which flows 1 350 km through extensive plains that are progressively more arid towards northern Sudan to reach the Egyptian border. In Upper Egypt, the High Aswan Dam (HAD) creates by far the largest man-made reservoir in the entire Nile river basin and regulates this vital source of water for multiple benefits downstream.

Climate of the Eastern Nile Region:

The elevated plateaus in Ethiopia experience cool to mild temperatures year round, whereas in central and northern Sudan the climate is hot year-round and very hot in the late spring and early summer (May to July). The far northern part of the Eastern Nile river basin in Lower Egypt experiences a Mediterranean climate, with mild winters and hot summers. Rainfall in Egypt is very low throughout the year with a low peak in winter months (December to February). Most rainfalls along the cost with 200 mm average in the wettest area near Alexandria. Some areas don’t receive any rains for many years and then experience sudden downpours that result in flash floods. Figures 2,3 and 4 demonstrate the rainfall distribution in Ethiopia, Egypt and Sudan respectively.

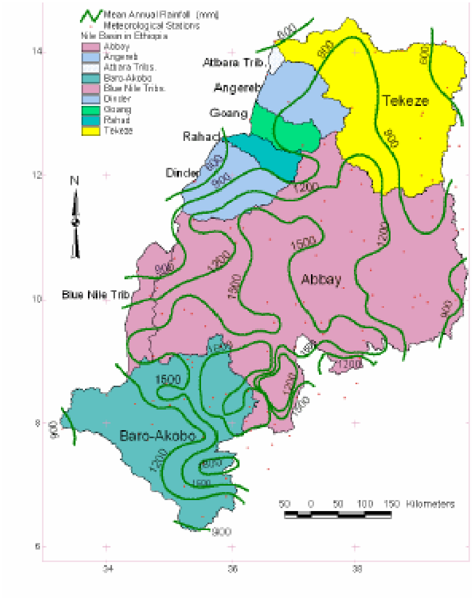

Figure (2) Rainfall Distribution in Ethiopia

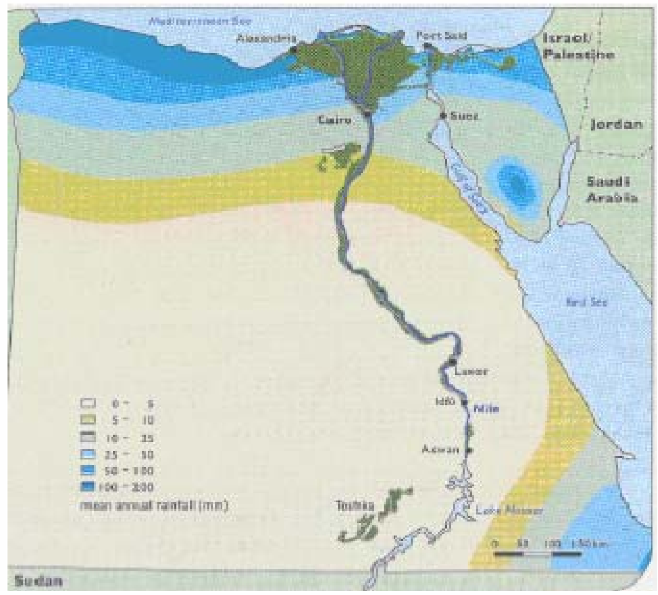

Figure (3) Rainfall Distribution in Egypt

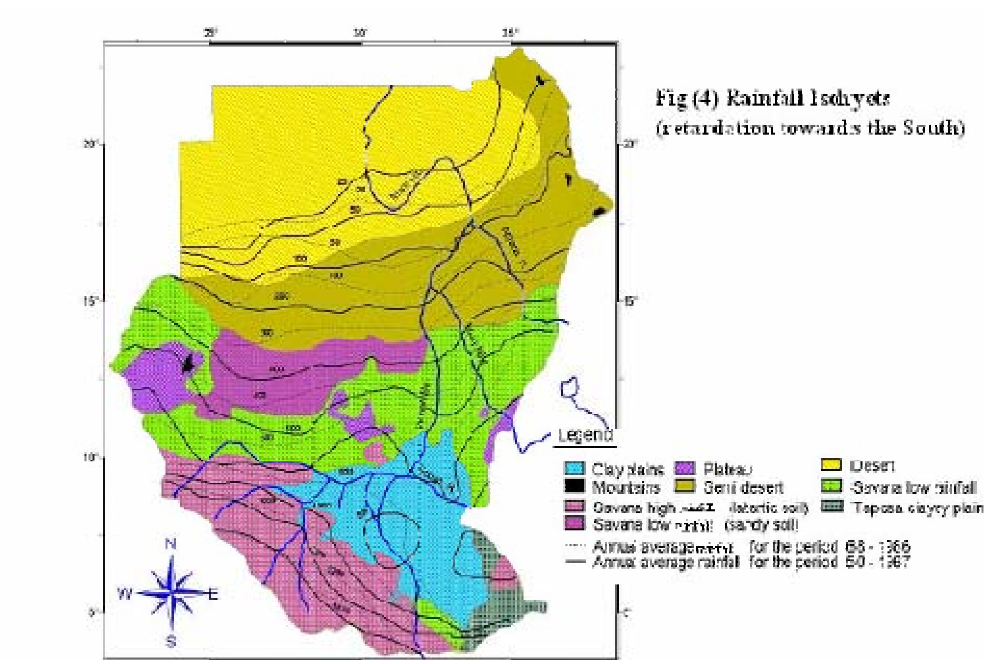

Figure (4) Rainfall Distribution in Sudan

Hydrology of the Eastern Nile Region:

Ethiopia:

From south to north, the main river sub-basins flowing from the Ethiopian highlands into Sudan are the Baro-Akobo, the Abbay and the Tekeze. The sub-basins are illustrated in Figure (5).

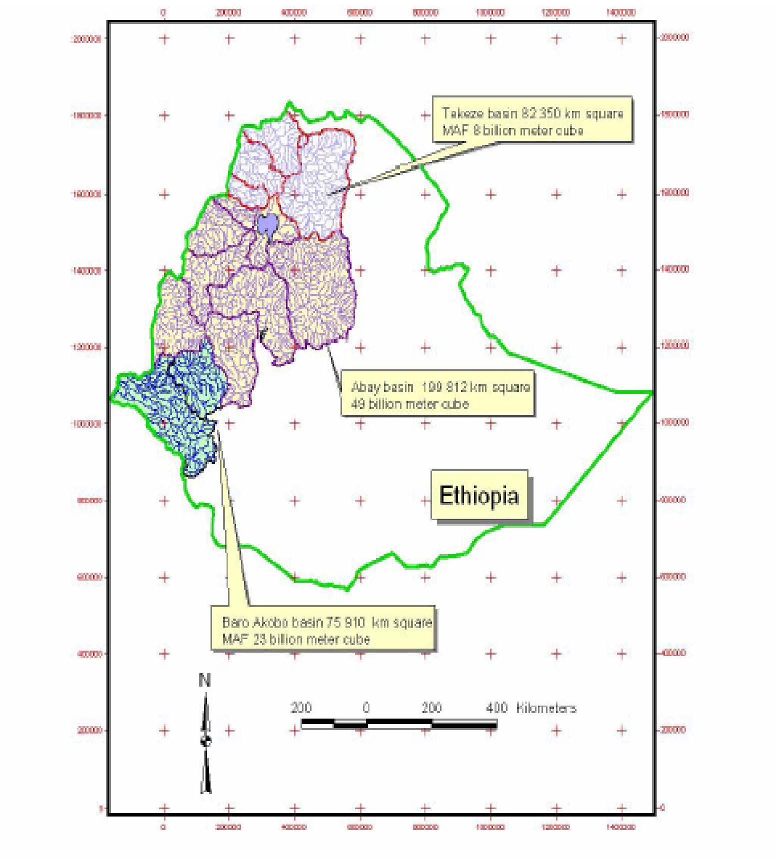

Figure (5) Nile River Basin in Ethiopia

The Akobo River defines the border with Sudan, access is very difficult from the Ethiopian side, and there are no river gauges on the Akobo River in Ethiopia. The Akobo from the south- east joins the Pibor flowing from the south out of Sudan, and the Pibor then defines the Ethiopian- Sudan border until where it is joined by the Baro flowing the east out of Ethiopia. The river then becomes the Sobat, and flows west through southern Sudan to its confluence with the White Nile about 800 km south of Khartoum. The only dam in the Baro- Akobo sub-basin is the Abobo Dam on the Alwero River tributary, commissioned in 1996. The catchment area to the dam is 1 043 km^2, and the maximum storage capacity is only 74 MCM. Regular widespread flooding occurs seasonally in the flat plain areas up-stream of the Sudan border.

The Abbay River flows out of Lake Tana at Bahir Dar, and spirals first south, then west, and finally north-west into the Sudan. On the way it is joined by many large tributaries, including the rivers Beshilo, Jimma, Muger, Guder, Finchaa, Didessa and Dabus on the left bank, and the Beles River on the right bank. The Abbay passes through deep valleys and gorges as a raging torrent during and after the wet season (July to October approximately), conveying large sediment loads. In the Sudan the Abbay is known as the Blue Nile.

Apart from a weir (Chara Weir) at the outlet of Lake Tana used to regulate lake outflows for a hydroelectric station at the Blue Nile Falls, there are no dams on the Abbay River; however the potential for hydropower dams downstream is currently being investigated. There is one dam on the Finchaa River tributary competed in 1973, where the catchment

area is 2 500 km^2. The maximum storage capacity of Finchaa Dam is 900 MCM. A tunnel is currently being constructed between Lake Tana and the Beles River tributary to tap the hydropower potential of Lake Tana, but there is no dam associated with the scheme. Another dam is currently being constructed for hydropower on the Koga River, a lesser tributary to Lake Tana. This storage will command a catchment area of only 164 km^2 , and will be of maximum capacity 77 MCM.
The Dinder River and Rahad River are other large tributaries flowing across the Ethiopian- Sudan border which join the Blue Nile on its right bank downstream in the Sudan.
Further north, the Tekeze River flows from near Lalibela first north, then west and north-west to the Sudan border at Humera where the catchment area is 63 375 km^2. Like the Abbay, it is deeply incised in highland plateaus and mountainous areas, and is joined by several tributaries within Ethiopia. Generally, the rainfall over the catchment of the Tekeze is lower than that over the catchment of the Abbay, there is less runoff per unit area, and the rivers may cease flowing in the drier part of the year. There were no dams in the Tekeze sub-basin, however a large dam- the Tekeze Dam- is currently under construction, primarily for hydropower generation. It will command an upstream catchment of 30 390 km^2, and will have an active storage capacity of 9 293 MCM, Table 1-2 shows some details of the dams constructed or being constructed within the Eastern Nile river basin in Ethiopia.

Table (1): River Regulation in Ethiopia

Name	River	Capacity ($m^3 x10^6$)	Catchment Area (km^2)	Year Commissioned
Abobo	Alwero (Baro-Akobo basin)	74	1 043	c. 1995
Chara-Chara Weir (L. Tana)	Abbay	9 000 [1]	15 300	1999
Finchaa	Finchaa (Abbay tributary)	900	2 500	1973
Koga	Koga (tributary to L Tana)	77	164	under construction
Tekeze	Tekeze	9 293	30 390	under construction

1. Capacity of Lake Tana

Two large tributaries flow across the Ethiopian-Sudan border and join the Atbara River on its left bank downstream in the Sudan. These are the Angareb River (catchment area 13 326 km2) and Goang River (catchment area 6 694 km2). In the Baro-Akobo sub-basin, very extensive flooding of rural areas in the Gambella occurs every year (Selkhozpromexport, 1990; TAMS/ULG, 1997). In years of high flood, inundation of parts of Gambella City and other townships can also occur. In the Abbay sub-basin, there are rural localities around Lake Tana that are seriously subject to flooding, either from the lake or from flows of tributary rivers in years of high runoff (eg. Ribb, Gumera, Megech rivers). The flooding causes serious hardship virtually every year in particular localities. Systematic river gauging commenced in Ethiopia only in the 1960s.

Numerous stations resumed operations in the early 1990s, and the MWR in Ethiopia has expanded the gauge network in recent years – particularly after bilateral Norwegian assistance – and plan to continue improvements to the network. At Humera on the Tekeze River, records have not resumed after the period of conflict due to ongoing border disputes with Eritrea. There are no real-time or virtual real-time reporting stations in the Eastern Nile basin that are currently useful for flood forecasting. Some stations have manually observed staff gauges and many have chart recorders.

Sudan:

Within the Sudan, main tributaries are those flowing from Ethiopia already noted above: the Dinder and Rahad which join the right bank of the Blue Nile, and the Angareb and Goang which join the left bank of the Atbara. As noted previously, the White Nile joins the Blue Nile at Khartoum to from the Main Nile. Table 2 compares the flow contributions of the White Nile, Blue Nile and Atbara Rivers to the Main Nile; The Blue Nile is the largest contributor to annual flow volume. However in the winter months the White Nile is the main contributor. Flows deriving from the White Nile at Khartoum are relatively stable throughout the year, where as flows from the Blue Nile vary substantially through the course of a year, While the annual volume of flows from the Atbara are comparatively minor, flood peak from the Atbara aggravate flooding along the Nile downstream if they coincide with high flows from Khartoum.

Table (2): Mean Annual Flows of the Main Rivers Contributing to the Main Nile in Sudan

	MAF (MCM)	Percentage of Total
Blue Nile	50 000	56.2 %
White Nile	27 000	30.3 %
Atbara	12 000	13.5 %

It has been estimated that of the flow from the White Nile at Khartoum, approximately 50% is derived from the Sobat River, most of which is runoff from the Ethiopian Baro-Akob sub- basin (Ahmed, 2006). Local rainfall in Sudan can also produce flash flooding in wadis draining to the River Nile. This contributes to flood risk; however it makes little difference to river flows.

There are two dams, Roseires and Sennar, on the Blue Nile upstream of Khartoum, and the Jebel Aulia Dam regulates the White Nile about 32 km upstream of Khartoum. There is also a large dam on the Atbara River, Kashm El Girba, Table (3) provides some relevant details. Gates in Roseires and Sennar Dams are opened at the onset of the annual floods to pass the high sediment loads conveyed by the Blue Nile, and then closed on the flood recession to capture water for the next dry season. Despite these precautions, substantial sediment deposition has occurred with consequent reduction in active storage capacity.

Table (3): River Regulation in Sudan

Name	River	Original Capacity (MCM)	Est. Current Capacity (MCM)	Year Commissioned
Rozeires	Blue Nile	3 350 *	1 900	1966
Sennar	Blue Nile	900	400	1925
Jebel Aulia	White Nile	3 500	n.a.	1938
Khashm el Girba	Atbara	1 300	600	1964
Merowe	Main Nile	12 450	---	under construction

* Rozeires: capacity after upgrading

A new dam is being constructed at Merowe on the Main Nile, roughly 800 km downstream of Khartoum near the 5th Cataract of the Nile downstream of the Atbara River confluence. It is planned that this dam will be operated in a similar mode to those of Roseires and Sennar in order to maximize passage of sediment through the storage during the rising stage and peak of the annual floods.

Sudan has a long tradition of river gauging dating from pre-independence years. In fact, Sudan has long records of good accuracy at many gauging sites along rivers.

Egypt:

The hydrology of Egypt is dominated by the Nile River and its regulation by HAD. The Nile is the only river in the country, there are no tributaries and the importance of this water source is heightened by the aridity of the climate which features low rainfall in coastal areas and very little rainfall at all in the interior.
HAD is located in Upper Egypt, and the lake it creates (Lake Nasser in Egypt, Lake Nubia in the Sudan) extends 500 km upstream into the northern limits of Sudan. The reservoir has a total storage of 163 00 MCM, which compares with the mean annual inflow of 84 00 MCM. As shown in Table(4), the total storage is divided into three zones. According to the design, the dead storage was sufficient to accommodate the sediment inflow over a period of 500 years. In practice, virtually all of the sediments are being deposited in the headwaters of the storage as the river waters slow down on entering the lake. Above around 178m, water also begins to spill laterally from the lake to the Western Desert through a depression known as Toshka Spillway. Any water above dead storage is available for release for irrigation, hydropower generation and to sustain minimum environmentally acceptable flows down the river and through the delta.

Table (4): Lake Nasser Storage Zones

Zone	Up to lake level (m)	Cumulative Storage Volume (m^3x10^9)	Surface Area (km^2)
Dead storage	147	31.6	1 737
Active storage	175	122	5 168
Flood storage	182	163	6 540

6.5 km downstream of HAD, the Old Aswan serves to re-regulate hydropower releases and generate additional power. See Figure (6)

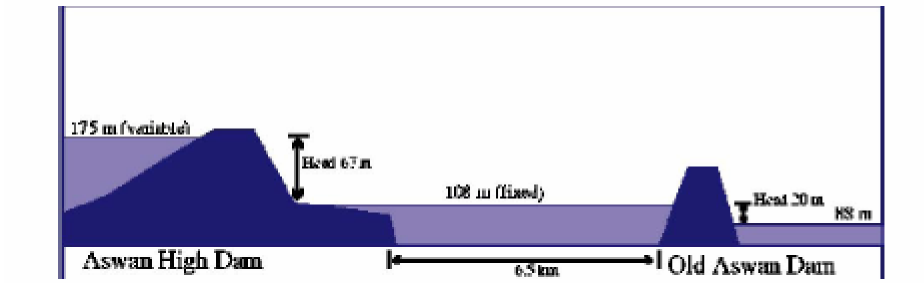

Figure (6) Regulation by High Aswan Dam and Old Aswan Dam

After commissioning, the storage filled over a period of almost 10 years, and annual releases were relatively stable for many years. During the severe droughts in the Ethiopian highlands during the 1980s, the lake levels declined progressively, remaining well below the flood storage pool for many years before beginning to recover commencing with the very large flood in 1988, see Figure(7). A sequence of generally above- average flood, commencing in 1998 and culminating in 2001, pushed lake storage well into the flood storage zone with releases of unprecedented magnitude since dam commissioning, and a record high lake level of approximately 181.6 m was reached in 2001.

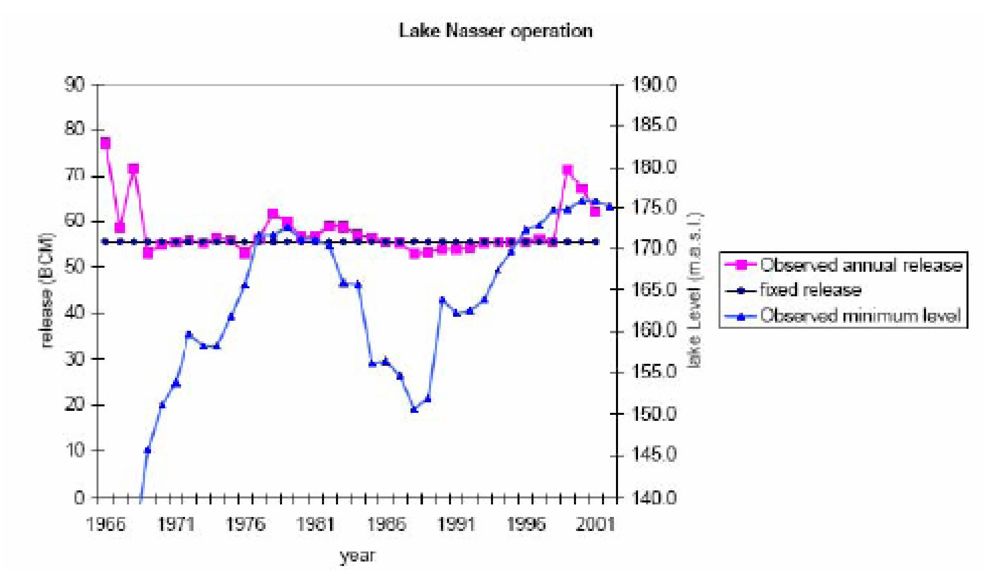

Figure (7) HAD Storage and Release Time Series

Downstream of HAD, the Nile continues a further 1 182 km to reach the Mediterranean Sea. The river between HAD and the delta is divided into four main reaches by a series of barrages. These are Esna, Naga Hammadi, Asyut and Delta Barrages. At the Delta Barrage the river enters the delta, bifurcating into two main branches, the Rosetta Branch and Damietta Branch.

Intensive irrigated agriculture is practiced along the entire length of the Nile River valley downstream of Aswan Dam, and in the delta, It is virtually the only arable land in Egypt.

The total area of irrigated land in year 2000 was approximately 7.7 million feddans ($3.25x10^6$ ha) and is expected to expand to 11 million feddans ($4.6x10^6$ ha) by the year 2017 partly due to the implementation of two new major projects: El- Salam Canal to North Sinai, and the Toshka scheme in the south adjoining Lake Nasser.

Although flash flooding still presents problems in Egypt, after construction of HAD flooding from the river was not a problem until a series of high flood years between 1998 and 2001. High rates of release were then necessary in operations of the dam, and it was found that rates of release in excess of about 250 MCM/d to 260 MCM/d did cause problems, including inundation of islands used for agriculture and of other encroaching development on the floodplain, partly due to unauthorized land use and partly because of inadequate land use controls over the intervening decades since commissioning of HAD. At the time of HAD design, flood releases of up to 350 MCM/d had been allowed for the passage of large floods such as the largest historical flood in 1878. High river flows also caused scouring at river structures (bridges and barrages), a problem aggravated by the low sediment loads downstream of the dams, leaving river flows with greater potential to degrade river beds and transport material.

Institutional Context

The governance structures and institutional arr angements in Ethiopia and Sudan have been in a state of flux as political systems have adjusted to the resolution of inter- and intra-national boundary issues through peace agreements. As a result, the strength of Government institutions, in the organizational sense, has been disturbed by the changes of reorganization and decentralization. The growth of institutions in the sense of developing "rules of the game" (i.e. policies, systems, regulations), which make the enabling environment for economic and social activity, have therefore also been held back.

Many institutional gaps have been attempted to be filled with the assistance of UN agencies and international NGOs during this period, particularly in Ethiopia.

The following recommendations are made to fill gaps in existing policies in flood management, and to strengthen institutional coordination arrangements in flood preparedness and response activities in Ethiopia and Sudan.

1. Institutional strengthening and capacity building is required for new and existing institutions
2. Ensure data sharing and dissemination between the three countries.
3. Develop institutional linkages among the various public and private sector organizations to be involved with land management planning in the urban localities and to assist in identifying which areas downstream of HAD are to be piloted to plan floodplain risk management procedures.

4. Policy research assistance is desirable to facilitate future floodplain management planning and infrastructure development:

Social Context

There is a lack of current and reliable socio-economic and environmental data in the Eastern Nile River basin. On the Fogera and Dembiya floodplains, most of those who are at risk from serious flooding are subsistence farmers. For them, floods are a necessary annual occurrence and, for the most part, communities have adequate knowledge of how to live with, and benefit from them. There is less capacity in these communities to deal with serious floods, however. The Gambella plain lies in south-western Ethiopia and is part of the Baro-Akobo river basin (Sobat River in Sudan). Gambella city is the regional capital, about 800 km from Addis Ababa. Severe flooding, estimated to be of annual exceedance probability 2%, occurred in 1988, during which most of the city of Gambella and other towns along the Baro River were inundated. Rural land on the Gambella plain that is subject to frequent flooding is essentially used for pasture and cattle.
Early warning systems, reliable communication systems, training and education, health care, public education on water treatment, institutional strengthening at community level, small scale structural intervention (roads, raised earth platforms, drains, levees, gabions, etc.), development of more effective water harvesting/irrigation systems and the to exploit floods and expansion of flood-based crop cultivation such as rice are the essential needs in flood-risk areas of Ethiopia.

Over the last ten years, heavy flooding was experienced in Sudan in 1998, 1999, 2001, 2002, 2003 and again in 2006. Socioeconomic impacts of these floods included the displacement of large numbers of people, the loss of agricultural crops, damage to agricultural inputs such as seeds and pumps, deterioration of health conditions due to the increased incidence of malaria and water-borne diseases, and disruption of social services such as education and health. Prior to this period, the country experienced very severe floods in 1878, 1946, and 1988.
The attitude of residents towards annual flooding along the Blue Nile and Main Nile mirrors the positive attitude of herders and farmers towards rains in the dry lands. A good flood season is an indicator of livelihood security. Most farmers along the Blue and Main Nile have a deep knowledge of flooding and are willing to endure the disadvantages of inundation because of the greater agricultural benefits they derive from them during the dry season. However, most communities are less capable of dealing effectively with flooding.
Major impacts of flooding include health problems, water supply and sanitation, poor drainage and bank erosion, in addition to agricultural and livestock losses. Official statistics indicate many homes are damaged or destroyed in larger than average floods, though this was only occasionally noted during community consultations.

There is a need in both urban and rural localities to develop flood preparedness and management capacity at the locality and community levels. Related to this is the need to develop more effective access by communities to government or public flood management and emergency relief services, particularly in the remote rural areas. External resources which improve the speed and efficiency of community effort, or which improve the technical quality and effectiveness of flood protection measures, and which provide greater access to resources for post-flood rehabilitation (in health, water supply, agriculture, etc.) are indispensable. In this way, flood mitigation and response is largely a joint effort involving the community, the government and NGOs.

<u>Examples of flood Damage:</u>

For most rural communities, the impacts of floods are not limited to property damage and immediate danger to life. Apart from property damage and disruption to productive activity, serious effects of flooding that demand attention also include epidemics of water-related diseases, including but not limited to surges in the incidence of malaria; loss of property and productive land by river bank erosion (haddam). Bank erosion and flood-induced disease are generally of greater concern to the riparian communities than the inundation of land when the river level exceeds bank height. Table (5) represents flood damages in Sudanese rural riparian villages. Table (6) represents flood damages in Fogera and Dembiya Plains, Ethiopia.

Table (5): Flood Damages: Sudanese Rural Riparian Villages

Damages estimated in US$ in 196 rural villages flanking the Blue Nile and Main Nile Rivers in Sudan

	Annual Exceedance Probability		
	1% AEP (1 in 100)	5% AEP (1 in 20)	30% AEP (1 in 3.33)
DIRECT COSTS			
Agriculture	133,750,000	88,275,000	
Farm residences	1	0	
Loss of permanent production through scouring	1,337,500	882,750	
Industry	0	0	
Commercial	400,404	40,954	
Housing	23,400,001	13,325,001	
Public Facility	13,970,001	6,732,501	
Recreational	1	0	
Vehicle losses	1,137,501	0	
Sub total	173,995,409	109,256,206	0
TOTAL DIRECT COSTS	173,995,409	109,256,206	0
INDIRECT COSTS			
Temporary Accommodation	7,137,000	3,568,500	
Temporary Water Supply	6,182,400	2,318,400	
Medical supplies, sanitation, etc.	2,760,000	1,380,000	
Recovery assistance - food, seeds, etc.	3,312,000	1,656,000	
Temporary Electricity Supply	13,000	1,950	
Deployment of Emergency Services	19,500,000	13,000,000	
Gathering food, fuel, water	2,340,000	1,170,000	
TOTAL INDIRECT	41,244,400	23,094,850	0
TOTAL COSTS	**215,239,809**	**132,351,056**	**0**

Table (6): Flood Damages: Fogera and Dembiya Plains, Ethiopia

Damages estimated in US$ in two main rural plains adjoining Lake Tana in Ethiopia

	Annual Exceedance Probability		
	1% AEP (1 in 100)	5% AEP (1 in 20)	100% AEP (1 in 1)
DIRECT COSTS			
Agriculture	9,102,273	3,146,591	
Farm residences	1	0	
Loss of permanent production through scouring	91,023	31,466	
Industry	8,100	1,800	
Commercial	115,604	11,344	
Housing	10,560,001	3,520,001	
Public Facility	155,001	74,001	
Recreational	1	0	
Vehicle losses	1	0	
Sub total	20,032,004	6,785,203	0
TOTAL DIRECT COSTS	20,032,004	6,785,203	0
INDIRECT COSTS			
Temporary Accommodation	1,143,000	284,625	
Temporary Water Supply	171,360	64,260	
Medical supplies, sanitation, etc.	76,500	38,250	
Recovery assistance - food, seeds, etc.	91,800	45,900	
Temporary Electricity Supply	5,040	378	
Deployment of Emergency Services	4,445,000	2,213,750	
Gathering food, fuel, water	495,300	123,338	
TOTAL INDIRECT	6,428,000	2,770,501	0
TOTAL COSTS	26,460,004	9,555,703	0

Availability of Flood Risk Related Data

In Ethiopia, access is a major limitation for siting of stations, and sites are virtually restricted to locations where there is road access. The road network is often limited. As there is no real-time or near real-time reporting, flood forecasting is impossible with the existing network of river gauging stations. A smaller network of stations equipped and operated to provide real-time data is a fundamental prerequisite. Resources for more regular maintenance and field measurements of discharge would also have to be strengthened to support such a network.

In Sudan, digital topographic data has recently been acquired along ~500 km of the Main Nile in relation to the Merowe Dam project. Khartoum State will also be covered within the next two years, and many river cross-sections have been surveyed and should be available from MIWR. The hydrometric network in Sudan operated by the Hydrological Stations Unit in the Nile Waters Department of MIWR is generally satisfactory, however it would benefit from the installation of several new stations on the tributaries to the Blue Nile and White Nile. Identification of flood risk areas is an important deficiency in the Sudan that limits the effectiveness of flood emergency response planning and preparedness. Digital topographic mapping should be produced for the entire length of the Blue Nile, the White Nile downstream of Jebel Aulia Dam, and the Main Nile to at least 100 km downstream of Dongola. Planning flood magnitudes from hydrological analyses should be used as inputs to hydraulic models to determine planning

In Egypt, recent digital topographic data has been obtained, and following the 2001 flooding, the Nile Research Institute has embarked upon a revision of the delineation of 'management lines', a rudimentary form of flood risk mapping. NRI are interested in benchmarking their mapping activity against international practice, and it is proposed that technical assistance be provided to undertake flood risk mapping similar to that proposed in Sudan. In Egypt, the current mapping program has included the acquisition of all digital topographic data and river cross-sections that are necessary.

The single greatest deficiency that can be rectified for future assessments of flood damage in all EN countries would be the preparation of flood risk mapping that would identify the exposure of people and property to flood hazard.Also the compilation of more accurate and detailed flood intelligence which can greatly facilitate estimation of damages in past (or future) floods is of great importance.

Flood Forecasting needs

In Egypt, the need for effective flood forecasting is further justified by the need to operate HAD to maximum efficiency and maximum benefit, as the regulation of Nile waters by the HAD has become a crucial aspect of the national economy. The Nile Forecast Center (NFC), situated within the Planning Sector of the Ministry of Water Resources & Irrigation (MWRI), has primary responsibility for flood forecasting in Egypt. It has developed models for short and medium term forecasting of inflows to HAD, and long-term simulation models for investigations of reservoir operations. The NFC is able to make near real-time estimates of rainfall in the upper Blue Nile basin.

In Sudan, the Nile Forecasting Center is a unit within the Nile Waters Directorate of the MIWR, and has several years' experience in use of flood forecasting models coupled with river gauging data reported from MIWR stations on the Blue Nile, Atbara and Main Nile. Components of the system became non-functional after several years of operation, and apart from an expert review in 2000; no serious efforts have been made to restore them since. Access to real-time data from Ethiopia would substantially increase the flood warning lead times available in Sudan. Forecast river levels should be disseminated to communities at risk in all circumstances when rivers are forecast to rise above 'alert' levels. Flood warnings should give equal weight to informal community preparedness and the preparations made by government agencies.

In Ethiopia, forecasting is more difficult than in the other Eastern Nile countries because shorter lead times are available, particularly for the flood risk areas around Lake Tana. Longer lead times for flood warning are feasible in the Gambella plains. No practical flood forecasting capability currently exists in Ethiopia. Furthermore, although there are a few weather stations that can report in real time to NMA in Addis Ababa, there are no river gauging stations equipped to report in real or near real time to MWR. That means that effective flood forecasting is impossible with the current network. In addition to flood forecasting, another challenge will be to develop a flood emergency response system capable of rapid response in locations remote from Addis Ababa. Therefore, the establishment of a Flood Forecasting Center and the installation of a real-time reporting network of rainfall and river gauges in Ethiopia is recommended in order to improve the capacity of Ethiopia to plan for and manage floods.

The recommended real-time reporting network of rainfall and river gauges will not only benefit Ethiopia, but will enhance the existing flood forecasting capabilities in the Sudan and Egypt

Flood Warning, Emergency Response and Post-Flood Relief and Recovery

Communities in Ethiopia respond to floods as they occur. There are some practices such as moving livestock off the lowest floodplain areas at the start of the flood season. Community flood preparedness and response is tied to the more frequent and smaller floods. Rarer, larger floods will almost certainly exceed this experiential capacity, as was evident during the big floods of 2006.

There is no dedicated flood emergency management agency in Ethiopia, and no formal flood emergency planning is undertaken. The DPPA is the one organization with experience in dealing with the impact of natural hazards including recovery from floods, but their planning efforts are primarily directed to the disasters of drought and famine. There is no formal process for recording the impact of previous floods or for estimating and recording what the consequences of future floods of different severity might be.

In Sudan, the CDO assume the role of a flood emergency management agency, and the HAC coordinate post-flood recovery and relief. However, there is no formal process for recording the impact of previous floods or for estimating and recording what the consequences of future floods of different severity might be. Annual reports by CDO provide only general numbers and lack accurate definition of locations, timing, corresponding river stage, or cause of flooding, and are of limited use as flood intelligence for management of future floods.

Without access to flood risk mapping or a Flood Intelligence System, and without a flood forecasting system that provides adequate lead times, advance risk-based scenario planning in advance of floods is very difficult. It is also recommended to establish national arrangements to define roles and responsibilities and to encourage civil society to collaborate in the planning process.

Flood Mitigation Planning

Ethiopian government has not undertaken any structural works to modify flood hazard within the areas of the Eastern Nile basin. The aggravating effects of high lake levels have already been mitigated by recent redevelopment of CharaChara Weir on the outlet of Lake Tana, and diversions from the lake for the Tana-Beles hydropower project currently under construction should further mitigate the impact of high lake levels on inundation of adjoining floodplains. Future dams being investigated for irrigation developments would modify but not eliminate the immediate down-stream flood risk if they proceed. Current construction of Tekeze Dam will also mitigate future floods downstream, including on the Atbara River in Sudan.

In Sudan, many riparian villages have developed systems of low levees (terraces) to provide a degree of protection from flood hazard during low to average floods. Some villages receive assistance from government or NGOs in these efforts. More formal levees exist in certain urban areas in the Sudan, particularly in Khartoum. Strategic town levees also exist in Dongola. Flooding on the Main Nile at Dongola will be affected by implementation of Merowe Dam upstream, currently under construction and preliminary analysis implied that the flood mitigation effect of the dam will be minor. Flood behavior, flood risk and flood benefits along the Blue Nile and Main Nile in the Sudan could be modified quite significantly by future construction of large hydropower dams upstream on the Abbay River in Ethiopia.

In Egypt, a high level of modification of flood hazard was achieved for all downstream reaches of the Nile with the construction of HAD 1968.

Watershed management can be an effective measure for flood risk management if pursued vigorously and applied over broad areas. The governments of Ethiopia and the Sudan have policies and plans for watershed management but they are having little practical effect due to lack of resources and extension work. ENTRO have identified watershed management as a priority which is being addressed by a parallel 'fast-track' Project (the Watershed Management Project) under the Eastern Nile Subsidiary Action Program (ENSAP) under the Nile Bain Initiative.

A related aspect that demands priority action in the Sudan (and Egypt) is river bank erosion.

Management of land use and land use practices on floodplain land can also confer many benefits by reducing exposure to flood hazard.

Flood Preparedness and Early Warning (FPEW) Project Summary

The Flood Preparedness and Early Warning (FPEW) Project is one of the fast-track projects identified for priority action under the Eastern Nile Subsidiary Action Program (ENSAP) as part of the Nile Basin Initiative (NBI).

Major objective:

The development objective of the FPEW project is to reduce human suffering and damages from, and capture the benefits of, flooding in the Eastern Nile. The project focuses on flood risk management and non-structural approaches to managing the impacts of floods: including floodplain management and flood mitigation planning; flood forecasting and warning; and emergency response and preparedness at regional, national, local and community levels. This will contribute to the longer term goal of establishing a comprehensive regional approach to flood management that integrates watershed, river and floodplain management, and incorporates a suite of structural and non-structural flood mitigation measures within a broad multi-purpose framework.

Expected Outcomes from the FPEW project include:

- Assessment of the flood risk in the Eastern Nile region to support flood management planning and ENSAP investment planning.
- Improved floodplain management for major urban centers vulnerable to flood damage, and for flood-prone rural communities.
- Operational flood forecasting systems in Eastern Nile countries with appropriate compatibility and mechanisms for exchange of information and data.

- Improved emergency response by governments at all levels, and enhanced community preparedness.
- Enhanced regional collaboration and cooperation during flood events.

Project Components:

The project was conceived as a number of proposed components, to be fully defined or modified during Project Preparation.

1. Flood Mitigation Planning

   This component was envisaged as proactive measures to manage the risk of floods while enhancing beneficial effects. It was intended to embrace practical measures to identify flood risk and implement community-based plans to manage flood risk.

2. Flood Forecasting and Warning

   Development of flood forecasting systems for the Eastern Nile countries is an important measure that should build upon existing forecasting systems and capacity.

3. Emergency Response and Preparedness

   To be most effective, response to a natural disaster warning should be rapid, comprehensive and with clear lines of authority. Because each country has existing organizations and procedures for emergency response, this component was envisaged as strengthening national capacities and developing trans-boundary aspects of emergency response and preparedness.

4. Regional Component

   This component is intended to enhance regional cooperation and collaboration through exchange of expertise and information/data, sharing of experience, professional development and institutional capacity building, and technology transfer regionally and inter-nationally.

The estimated total cost of all Project elements is $42.2 M.

Proposed Measures for FPEW Project implementation

- Programs to install secure sealable food storage in houses or communal locations, with construction materials resistant to prolonged inundation of foundations.
- Refuges for women and children elevated above flood levels; and cattle refuges.
- Construction of flood-proof courses at the base of dwellings where houses are damaged by prolonged inundation;
- New construction techniques that support housing above ground and above flood levels.

Other developments have considerable potential to reduce the vulnerability of those exposed to flood hazards as access roads or footpaths; improved telecommunications; agricultural extension work to combat pests brought by floods and preventative health programs.

A pilot study is recommended to try appropriate technology approaches to bank stabilization for rural areas.

For urban areas in Gambella Ethiopia and Dongola in the Sudan, development of flood protection works is proposed for inclusion in Project implementation.

Technical assistance to the relevant government agencies in Khartoum State is proposed to develop a unified land management policy and improve urban land management planning – particularly in relation to management of urban riparian land. Some assistance is also proposed to support land use management in the master plan for Bahir Dar.

A proposal was also developed for a field sampling program in the three rivers of Khartoum followed by a detailed research program of hydraulic and sediment transport modeling. The research findings would provide a knowledge base of hydraulic behavior in the urban reaches of the rivers that could be used in review of future works, and the models could be applied to evaluate specific proposals for future riparian development.

The problems of scour and bank erosion when high releases must be made from HAD are to be addressed with a program of field sampling and scientific research using hydraulic and sediment transport modeling for a pilot reach of the Nile in Egypt where bank erosion, scour and/or channel morphology instability are an element of flood risk to existing development.

Once detailed flood risk spatial information is available downstream of HAD, the next step towards comprehensive flood risk management is the preparation of a Floodplain Risk Management Plan that will guide future development of riparian and floodplain land, and link with statutory land use planning. This will be an entirely new step for Egypt (and within the EN region), and it is proposed that technical assistance is provided so that international specialists can work with local specialists to develop a preliminary Floodplain Risk Management Plan linked to land use planning for a pilot area.

Regional Activities

One important aspect of the FPEW Project is to develop mutual understanding and support between the regional countries of the Eastern Nile in relation to flood management. Some of the initiatives proposed in preceding chapters will require regional cooperation and exchange of data and information – most notably the development of a shared real time reporting network of river and rain gauges. Initiatives like this involve regular interaction that will engender good will and trust, and will benefit all participants by developing a shared vision for learning and technical development, greater exchange of technical knowledge and better flood management. However, regional specialists working in flood management will also derive benefit from special initiatives that provide a formal framework for technical exchange of data and advice. This should include an entire range of joint activities supported by the FPEW project as annual post-flood conferences; joint study tours; technical seminars and conferences; visiting specialists…etc.

Table (7): Ethiopia Sub- Program Summary

Item	Description	Remarks
1-E	Flood risk mapping	Lake Tana district. Acquire, analyze satellite imagery for digital topographic data and exposure to flood hazard. Develop DEMs in selected areas incl. hydrology/hydraulic analysis, Review Baro-Akobo mapping.
2-E	Network of reporting river gauging & rain gauge stations.	>50 rain gauges, almost 30 river gauging stations. Assume rehabilitation of ~15 stations, ~8 new stations, satellite data transmission. All sites require digital data logging and data transmission equipment.
3-E	Establishment of flood forecasting center in Addis Ababa	Building renovation, IT equipment, communications; development of forecasting models for Ribb, Gumera, Megech and Baro Rivers; training; specialist supervision for 2 y.
4-E	Capacity building at DPPA	Guideline procedures for DPPA +training. New unit for flood emergency response planning.
5-E	Capacity building at regional & woreda levels	Guideline procedures +training for woreda staff. L.Tana area only (Fogera, Libo Kemkem, Dembiya). NGOs to assist.
6-E	Capacity building at MWR	Training, equipment at H.O. to increase productivity of hydrological data management services. Field equipment.
7-E	Capacity building in NMA / MWR regional offices	Staff training, computers, equipment, communications.
8-E	Community education and training for awareness and preparedness	Guidelines for developing community self-reliance +training trainers, who will then educate / train communities for self-reliance and self-organization. Support for community-driven action plans for flood preparedness and self-management.
9a-E	Flood protection works, Gambella	Preliminary survey & investigations.
9b-E		Design & construction of levees, drainage works for urban flood risk area.
10-E	Land management planning	Technical assistance, Bahir Dar

Table (8): Sudanese Sub- Program Summary

Item	Description	Remarks
1-S	Flood risk mapping	Acquire & analyze satellite imagery. Undertake pilot test. Acquire accurate topographic data. Delineation of inundation extents. Identify exposure to flood hazard.
2-S	Hydrology & hydraulic modeling	Hydrology & hydraulics of planning floods to determine planning flood levels.
3-S	New reporting river gauging stations	Assume 3 new stations on Atbara, + 1 replacement cableway + 1 AWLR; 2 new stations on Dinder& Rahad.
4-S	New reporting weather stations	15 stations, with new data transmission + 2 laptops to download data from on-site digital data loggers.
5-S	Capacity building at MIWR	Reinstate flood forecasting system. Upgrade computer hardware, GIS software, rehabilitate materials testing laboratory.
6-S	Community education and training for awareness and preparedness	Guidelines for developing community self-reliance +training trainers, who will then educate / train communities for self-reliance and self-organization. Support for community-driven action plans for flood preparedness and self-management.
7-S	General capacity building for MIWR	Equipment and training to support regional offices and field programs of data measurements. Data management.
8-S	Capacity building at SMA	Upgrading SMA facilities – PCs, mass storage devices, software upgrade, training: assume 1-month on-site training by 2 specialists.
9-S	Capacity building for CDO	Guideline procedures for CDO + training, at national and state levels. New unit for flood emergency response planning.
10-S	General capacity building at CDO	Equipment, vehicles, communications.
11-S	Capacity building for HAC	Guideline procedures for HAC + training at national and state levels.
12-S	General capacity building at HAC	Equipment, communications. Establish office in Dongola.
13a-S	Flood protection levees, Dongola	Preliminary survey & investigations. Undertake structural, geotechnical audit.
13b-S		Design & construction. Reconstruct flood protection works where necessary.
14-S	Land Management planning, Khartoum	Technical assistance.
15-S	Investigations of river hydraulics, sediment transport and channel morphology	Program of field sampling, Khartoum rivers – bathymetry, sediment sampling, velocity profiles, materials sampling, etc. over a period of 16 months commencing July. Hydraulic modeling of flows & sediment transport, Khartoum.
16-S	Pilot study on bank erosion	Investigate & trial appropriate waterway management techniques to combat *haddam*.

Table (9): Egypt Sub- Program Summary

Item	Description	Remarks
1-EG	Upgrade NFC	Upgrade computer equipment, software, training
2-EG	Studies related to flood forecasting	Studies to determine effectiveness of improved flood forecasting procedures, related to HAD operations.
3-EG	Revise flood forecasting procedures	When expanded data network comes on line.
4-EG	Assistance with flood risk mapping	Technical assistance and study tour.
5-EG	Sediment transport modeling of pilot reach	Technical assistance for field sampling program and sediment transport modeling.
6-EG	Land use management	Technical assistance for pilot Land Use Management Plan in flood risk area, and study tours.

Table (10): Regional Sub- Program Summary

Item	Description	Remarks
1-R	Management unit support for ENTRO	Capacity building, funding support for RFCU.
2-R	EN flood management interest group in NBCBN	Facilities, management, travel budget over 5 y. Website establishment.
3-R	Annual conferences	Annual post-flood conferences, biennial technical conferences – travel, accommodation, venues, etc
4-R	Special topic seminars	Travel, accommodation, venues, etc over 4 y for 3 seminars with 8 participants from each country
5-R	Joint study tours	Assume 20 persons: Fees for institutions providing time/services.
6-R	Visiting specialists	Assume 6 persons
7-R	Joint studies	Assume 4 joint projects

References:

Snowy Mountains Engineering Corporation SMEC International (December 2006): Eastern Nile Technical Regional Office, Addis Ababa, Project Preparation Flood Prepardness and Early Warning Technical Background Paper,

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Abdel Ati, H A (2005): A Baseline Social Survey Report, Sudan. Prepared for The World Bank. Khartoum, July 2005.

Aziz, M & Sadek, N (2003): The proposed operation for the new Toshka Barrage. Engin.Res. Journal, **89**, Oct.2003:c85-c101.

Bakhiet, H Y (2004): Sudan's Background Information. Prepared for ENTRO.

Cawood, M (2005): An Initial Rapid Appraisal of Flood Damages along the Blue and Main Nile Rivers in Sudan. Draft report prepared for The World Bank. November 2005.

CBS (1999): National Report, 1999. Sudan Central Bureau of Statistics.

CSA (2004): Statistical Report. Report by Central Statistical Authority, Addis Ababa.

Delft Hydraulics (2002): Inception Report: Lake Nasser Flood and Drought Control Project. Prepared in association with COINS Hull Univ. & Royal Haskoning WREM for Ministry of Water Resources & Irrig. Nile Forecasting Center. Cairo, August 2002.

ENTRO (2006a): Social Atlas. January 2006.

ENTRO (2006b): Project Proposal for FPEW 1. Flood Preparedness and Early Warning Project in the Eastern Nile. Draft. Prepared for submission to The World Bank. October 2006.

EPA (2003): State of the Environment Report of Ethiopia. Environmental Protection Authority, Addis Ababa.

Ethiopian Govt (1993): National Policy on Disaster Prevention and Management. Transitional Govt of Ethiopia. July 1993.

EWRA (1980): General Report: Ribb & Gumara Flood Control & Irrigation Project. Ethiopian Water Resources Authority, Land & Water Studies Agency. Addis Ababa, 1980.

Fahmy, A (2006): One-System Inventory, Water Resources Theme (Egypt). Draft. Prepared for ENTRO Joint Multipurpose Project. Cairo, January 2006.

Golla, S (2004): Country Background Report, Ethiopia. Prepared for ENTRO.

Heynert, K V (2000): Sudan Flood Early Warning System. Prepared by WL / Delft Hydraulics. December 2000.

Monenco (1992): Merowe Multi-Purpose Hydro Project. Stage II Draft Report. Prepared for Sudan Ministry of Irrigation & Water Resources & National Electricity Corporation. June 1992.

MWR (2002): Main Report: Water Sector Development Programme 2002-2016. Ministry of Water Resources, Ethiopia.

NFC (1995): Monitoring, Forecasting and Simulation Project. Nile Forecast Center, Ministry of Public Works, and Water Resources Planning Sector. Egyptian Government, 1995.

Sadek, N, Attia, K & Fahmy, A (in preparation): Highlights on high flood effects on River Nile. Submitted for publication.

Seid, A H (2004): Flooding Extents and Coping Mechanisms in the Eastern Nile (An Overview). ENTRO, Addis Ababa, July 2004.

Shalaby, A el-R M (2002): Experiences in managing the reservoir of High Aswan Dam of Egypt. Symposium on Reservoir Management in Tropical & Sub-Tropical Regions. Intl. Commission on Large Dams (ICOLD), Iguassu, Brazil, September 2002. pp.42-56.

SMEC (2005a): Consultancy Services for Flood Preparedness and Early Warning Project. Proposal submitted to ENTRO, June 2005.

SMEC (2005b): Review and Updating the Economic Viability of Heightening Roseires Dam. Prepared for Sudan Ministry of Irrigation & Water Resources. July 2005.

SMEC (2005c): Ethiopia-Sudan Power System Interconnection Project. Environmental and Social Impact Assessment. Report prepared for ENTRO, November 2005.

UNDP (1996): Gambella Floods Report. Prepared by UNDP Emergencies Unit for Ethiopia. August 1996. www.sas.upenn.edu/African_Studies/eue_web/gambel96aug.htm

World Bank (2005): Ethiopia at a Glance. ww.devdata.worldbank.org/AAG/eth_aag.pdf

World Bank (2005): Egypt at a Glance. www.devdata.worldbank.org/AAG/egy_aag.pdf

World Bank (2005): Sudan at a Glance. www.devdata.worldbank.org/AAG/sud_aag.pdf

WMO (2005): Hydrological Information Systems for Integrated Water Resources Management: WHYCOS Guidelines. World Hydrological Cycle Observing System, World Meteorological Organization report WMO/TD no.1282, October 2005.