Eastern Nile Planning Model, Integration with IDEN Projects To Deal with Climate Change Uncertainty and Flooding Risk

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Abstract

The Nile basin (NB) is one of the biggest river basins. Ten riparian countries contribute to the basin. The NB is one of the least developed basins. It is 3 mill km^2 areas, with 1700 BCM/year of rainfall, and average annual natural flow of 84 BCM. The NB comprises 5 climatic regions that vary from Mediterranean, to semi arid, arid, subtropical and tropical regions. Also the topography of the Nile Basin varies from very high mountainous areas, more than 5000 meter above sea level to flat area. These varieties in climate, topography and locations give lots of opportunities in developing the Nile basin. It also makes the Nile basin vulnerable to foreseen climate change.

The Nile basin is also characterized with high level of poverty, low access to power, civil wars, lots of untapped resources; water shed degradation, low efficiency of water use, low access to water and sanitation. However, there are lots of opportunities that include hydropower productions, power interconnection, flood preparedness and early warning; water shed management, irrigation and drainage, integrated water resources management in the whole basin. All these opportunities will be combined with capacity building activities in the whole basin.

The Nile Basin Initiatives since its launching identified two major programs that are the shared vision program and the subsidiary action program. While the first program focus on capacity and confidence building in the whole Nile Basin, the second program focus on action on the ground through the identification and implementation of two sets of projects, fast track projects which are short term project and joint multi purpose program that focus on the development and implementation of investment projects in two main regions, the Nile Equatorial Lake (NELSAP) and Eastern Nile subsidiary (ENSAP) action programs.

The combined effect of rapid population growth in the Eastern Nile and rising development rates has led to a substantial increase in water demand. It is a truism that the Nile is the most important source of water for the region, and it follows that the climate change effects will change the water policy and will be one of the important determinants of the balance between demands and supplies in the future.

The eastern Nile planning model is one of the fast track identified projects within the Eastern Nile. The Eastern Nile Planning Model (ENPM) Project is designed to provide an effective planning tool to decision-makers in the Eastern Nile Region so that they can make informed water resources investment decisions. The project contains three major components: (i) The Modeling System, (ii) the Information Management System (IMS), and (iii) Institutional and Human Capacity Strengthening. So the ENPM Modeling System can be used to simulate the Nile Basin hydrologic conditions and evaluate economic, environmental, and social impacts of proposed water resources investments.

Climate change is one of the cross cutting issues that its impacts need to be considered in any planning process, especially we are talking about integrated development of the eastern Nile. Because planning aspects target the future, we have to anticipate the risks and uncertainties. Climate change is considered as one of the risks that might face the future development within the eastern Nile that has to be considered.

This paper addresses this issue in details and discusses how to incorporate and quantify the impacts of climate change in modeling efforts that we are conducting within the Eastern Nile.

Key words: Climate Change, Nile hydrology, Eastern Nile planning model

1. INTRODUCTION

The Nile River is the longest river in the world, stretching approximately 6,700 km from its remote headwaters in eastern Africa to the Mediterranean Sea. The Nile and its tributaries flow through ten

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countries and the river basin drains over three million square kilometers (one tenth of Africa's total land mass) and is home to more than 300 million people (many of them are among the world's poorest). Because of its size and variety of climates and topographies, the Nile is one of the most complex river basins in the world.

Figure1 The Nile basin

The Nile (figure 1) originates from its major source, Lake Victoria forming the White Nile that flows generally North through Uganda and into Sudan where it meets the Blue Nile at Khartoum. From the confluence of the White and Blue Nile, the Main Nile River flows northwards into Egypt and to the Mediterranean Sea. The Eastern Nile includes the countries of Ethiopia, Sudan, and Egypt, and encompasses the sub-basins of the Baro-Akobo-Sobat, the Blue Nile, the Tekezze-Settit-Atbara, portions of the White Nile in Sudan, and the Main Nile. All flows in the Nile are the result of rainfall upon the Ethiopian highlands and the Equatorial lakes region.
While this rainfall is usually plentiful, it is not always consistent from year to year. The annual average rainfall over the entire Nile basin is approximately 600 mm, ranging from 1200-1600 mm at the headwater regions to near zero at the most northern part of the basin. The seasonal fluctuations of rainfall in the Ethiopian highlands are much greater than those at the source of the White Nile. However, depending on the strength of the monsoon over Ethiopia, the total flow volume from year to year can vary dramatically.

There are two major basins within the Nile basin. These two major basins are the eastern Nile that is composed of Abbay (Blue Nile), Tekeze (Atbara), Baro Akobo (Sobat), and the Nile Equatorial Lake that is composed of mainly Lake Victoria basins, sudd swamp are in south Sudan.
The White Nile flows from the tropical rain belt of Central Africa, and its principal source is Lake Victoria. As the White Nile flows north, it enters Sudan and then the Sudd marsh area, where the flows leave and re-enter the channel depending on the season. Much of the flow at this point is lost by evaporation. Downstream of the Sudd, the White Nile is joined by flow from the Sobat River that drains from the Ethiopian highlands. From this point to Khartoum, (about 800 km) nearly half of the flow in the White Nile is from the Sobat. South of Khartoum, the British built a dam (Jabal al Auliya Dam) in 1937 to store the water of the White Nile and then releases it in the fall when the flow from the Blue Nile slackens. Much water from the reservoir has been diverted for irrigation projects in central Sudan however; it merely evaporates, so the overall released flow at the downstream is not great.
The Blue Nile rises in the highlands of Ethiopia and its flow is strongly influenced by the annual monsoons from the Indian Ocean to the East. The main source of the Blue Nile is Lake Tana in Ethiopia. The river flows west then North until it eventually meets the White Nile at Khartoum. During a big portion of the year, the Blue Nile is the smaller of the two rivers, its flow usually accounts for only one-sixth of the total Nile River flow. In August, however, the rains in the Ethiopian highlands swell the Blue Nile until it accounts for 90% of the Nile's total flow. During high water time, the Blue Nile is navigable in a reach of 800 km.

2. CLIMATE CHANGE AND IMPACTS ON THE NILE

Sayed, 2004 recognized that there is an increase in the temperature rates over the eastern Nile during the last 20 years, table 1. The future climate changes have been investigated by (Wigley 1993). The results predicted a warming of about 3.5° C spreading uniformly over the seasons, with most of the Mediterranean basin showing an increase in precipitation in winter and increase of rainfall over the eastern Nile basin (Sayed 2004). Recent and predicted future precipitation changes over the Nile basin (Hulme 1989), and monitoring of the upper White Nile catchment, upper Blue Nile catchment, and Middle Nile Basin from 1880 to 1989 showed declination in the total precipitation, however; it was recognized that there is an increase in the precipitation over the Eastern Nile (Sayed 2004).
Global circulation models (GCM) for 1861 - 1988 show an overall warming of 0.5° C for this period, this increase have been verified by observed data from 1990 to 2004 (Sayed 2004). Various GCM models have been applied to study the potential climate change impacts on the Nile Basin (Saleh et al. 1994). Conway (2005) has shown that for the Blue Nile basin, a slightly increasing trend in rainfall was observed between 1905-1965, followed by a prolonged decline reaching its minimum in 1984, and then recovering significantly during the 1990s. A similar finding was reported by Funk et al. (2005), who examined rainfall patterns in Ethiopia since 1960 for June-September. Funk et al. (2005) also noted that the months of March-May had experienced a sharp decline in rainfall over Ethiopia since 1960. They argued that this was most likely because positive temperature anomalies in the southwestern Indian Ocean may have increased oceanic precipitation and reduced rainfall over eastern Africa.

Table 1 Temperature Change over the Eastern Nile Basins

Year	Average Temperature	Temperature Change
1949-1959	13.97	-0.86
1960-1969	14.86	0.02
1970-1979	15.66	0.82
1980-1989	14.86	0.02
1990-1999	15.27	0.44
2001-2007	15.37	0. 54

Figure 2 shows the ITCZ movement over Africa, it is clear that the longer the ITCZ stays in the North, the more vulnerable the area to flooding, on the other side when it stays longer to the south, more droughts are expected.

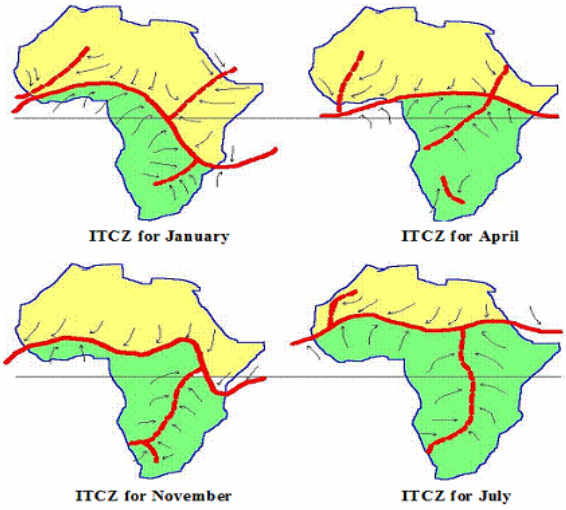

Figure2 Annual progression of ITCZ over the Nile basin

The Eastern Nile economy is largely based on agriculture. While there are ambitions plans for agriculture expansion, water availability is the main constraint on the expansion of agricultural land. Despite having very high potential for agriculture production, many Eastern Nile countries still imports a large percentage of their food, which makes it vulnerable to the world food market. Yates (1996) and Strzepek et al. (1994) indicated large implications of climate change on the agricultural sector of Egypt. These effects are realized through two mechanisms; the change in agricultural production around the

world changing crop production and prices, and the change in agricultural activities adapting to changes in water availability within Egypt.
The short period of flood months (5 months from June-October) makes the Nile basin vulnerable to floods and droughts as well. So, within the Nile basin, climate change can be seen as a threat or as a potential opportunity. It is a threat if the regional cooperation does not start, this will lead to unplanned and uncoordinated development that will put more stress on water demand without consideration of water availability and also environmental degradation. On the other hand, it is an opportunity, once the regional cooperation starts and integrated coordinated developments of different basins is considered as a key element for the sustainability.
Sayed 2004 has recognized the temperature increase over the Eastern Nile and at the same time the increase of the overall runoff of the Nile. This increase can be attributed to the increase of precipitation rates that is accompanied by severe watershed degradation that leads to the increase of the net runoff. Table 1 shows the temperature change and table 2 shows the flow changes.

Table 2 Average Flow and Its Change at Blue, White and all Nile Basins

Period	Diem		Malakal		All Nile	
	Flow	% difference	Flow	% difference	Flow	% difference
Before 1960	50.4	0	27.6	0	78.0	0
1961-1997	46.4	-8	32.9	+19	79.3	+2
1998-2003	58.3	+17	34.1	+25	92.4	+20

3. THE NILE BASIN INITIATIVE (NBI)

The NBI is a regional partnership 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".

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) a Subsidiary Action Program, focusing on sub-basin projects to deliver development projects involving two or more countries.

3.1 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 seven projects[1]:

- Eastern Nile Planning Model Project[2]
- Flood Preparedness and Early Warning Project
- Ethiopia-Sudan Transmission Interconnection Project
- Irrigation and Drainage Project
- Watershed Management Project

[1] There are also references to an "SVP Coordination Project" in the NBI literature but it is not clear if this is an eighth SVP project, or something different.
[2] The ENSAP Project Identification Document (PID) was prepared in 2001. That was the first document outlining the general goals, objectives, and activities for the ENPM Project.

ENSAP's regional/multi-purpose projects include:

- Baro-Akobo Multi-Purpose Water Resources
- Development
- Eastern Nile Power Trade Investment Program Study
- Joint Multi-Purpose Program

3.2 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).

3.3 The Eastern Nile Planning Model

All the previous ENSAP projects will require existence of knowledge base as well as analytical tool to study different impacts.

The knowledge base will be an essential part of the ENPM, where all the data and information collected and generated from different ENSAP projects will be organized, stored in a unified knowledge base. This knowledge base will be a key element for managing different data sets and also doing analysis as well as to be used as a key input into different modeling system. Figure 3 illustrates the role of ENPM in synchronizing eastern Nile projects' collected data and generated information.

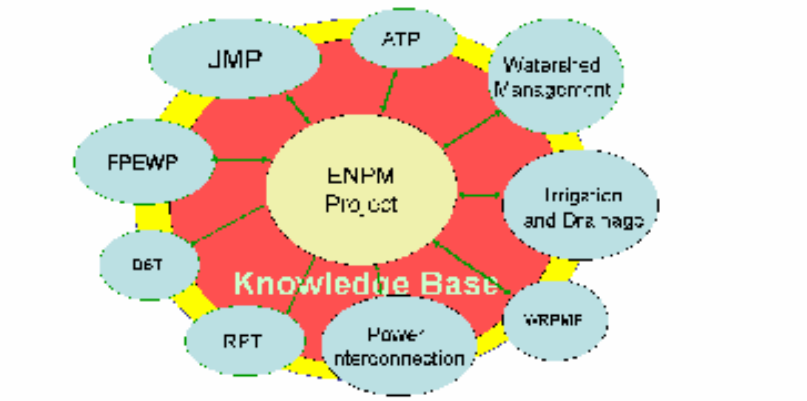

Figure 3 Role of Eastern Nile Planning Model in knowledge building and linking different projects' information

The second component within the ENPM is the analytical tool that will take the role of studying different impacts, on socio economic, environmental, and financial and also on flow regime and changes, of proposed project. Figure 4 shows the general scheme of the development of the eastern Nile Planning model.

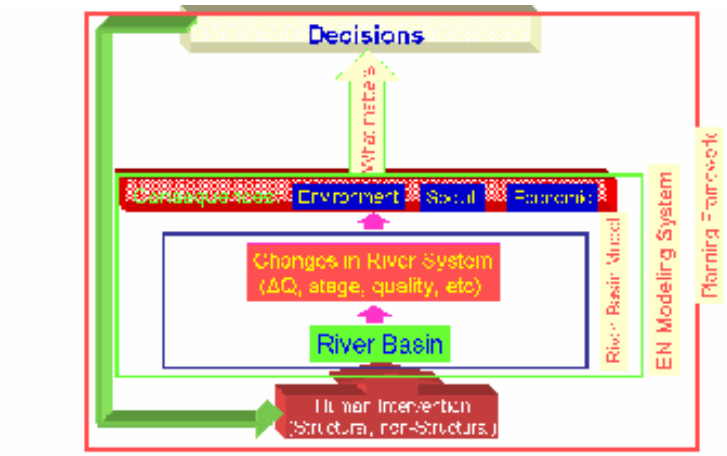

Figure 4 Key components of the Eastern Planning Model

Climate change is seen as one of the major uncertain external factors that might affect the overall water resources development and management within the Nile basin. The reason for that is that there is current condition that is affected by driving forces combined with sideswipes that will lead to future states that are mainly governed by the foreseen actions to reduce global emissions which represent high uncertainty in future spatial and temporal distribution of rainfall patterns along the Nile basin. The eastern Nile planning model will play a crucial part in studying the impacts of different projects combined with possible impacts of climate change that might affect their feasibility. The eastern Nile planning model will enable the decision makers to address and get possible answer and scenarios for some of the following key questions that relate mainly to climate change:

What are the implications of climate change, using available IPCC climate change scenarios, on rainfall patterns (spatial and temporal), temperature patterns (spatial and temporal), evapo-transpiration implications (including current and major planned EN reservoirs), runoff, sea-level rise inundation (under various scenarios), water quality implications, evaluate approximate salinity implications in Egypt in a scenario with:

Reduced spills from Aswan, rising sea levels in the Mediterranean, subsidence of delta land, the approximate impacts of low-flows on surface and ground water interactions, the implications of land-use changes when viewed in a regional context, e.g. Watershed development (including forestations and check dams), continued watershed degradation, urbanization.

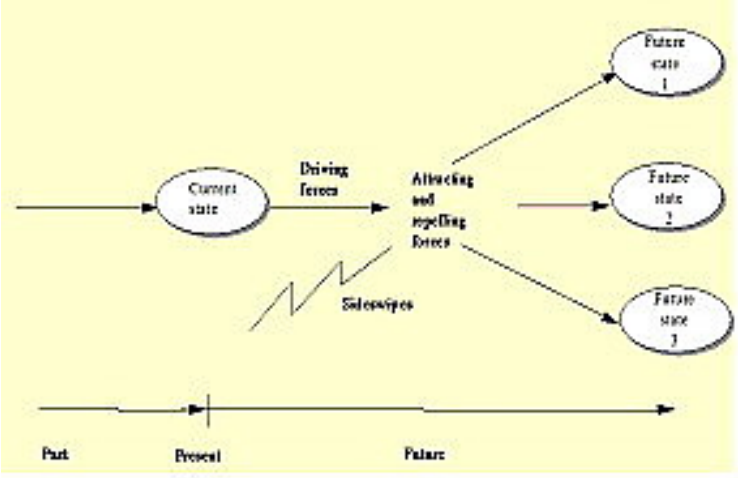

Figure 5 Climate change uncertainty

4. CONCLUSIONS

The development of the Eastern Nile planning model is vital for the long term planning and development of the eastern Nile basins. There are three major components that are the knowledge base, analytical tool, and capacity building.

Climate change will be a major element to be considered in all future planning and studies of different development projects, the ENPM will help in studying different impacts and uncertainties of climate change on future development projects.

Climate change risks and uncertainties in the integrated development of the Nile basin can be addressed through the following:

- Calibration and validation of a regional climate model to test the impacts of extreme scenarios on the spatial and temporal distribution of rainfall over the Nile Basin.
- Development of basin simulation tools with reasonable resolution that can convert these rainfall patterns into river flows
- Development of multi criteria analysis tool that will look at different impacts and trade offs in terms of vulnerability
- Development of economic impact assessment tool that will enable quantifying the costs and benefits of different interventions and to what extent these intervention will impact project feasibility
- Development of GIS modeling tool that will enable quantifying the impacts on communities through addressing current and future land use and land cover scenarios and proposing future scenarios
- Assessing the vulnerability of communities
- Proposing mitigation and adaptation plans with some clear costing figures
- Testing communities' resilience to extreme events and proposing mechanisms to increase it.

This can be achieved through coordinated research and cooperation at national, regional and international levels.

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