AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Irrigation and Hydraulics Department

Management of Eastern Nile Basin Water Infrastructure

A Thesis Submitted in Partial Fulfilment of the Requirements of the Degree
of
Doctor of Philosophy in Civil Engineering
(Irrigation and Hydraulics)
by

Rasha Hosny Abd El Monem
Master of Science in Civil Engineering
(Public Works)
Faculty of Engineering, Ain Shams University, 2011

Supervised By

Prof. Dr. Iman Mahmoud Elazizy
Professor of Hydraulics and Water Resources
Irrigation & Hydraulics Department, Faculty of Engineering
Ain Shams University

Dr. Iman Sayed Ahmed
General Director, Planning Sector
Ministry of Water Resources and Irrigation

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Dr. Abdallah Sadik Bazaraa Prof. of Irrigation and Hydraulics Irrigation and Hydraulics , Cairo University	…….
Prof. Dr. Abdel Kawi Khalifa Prof. of Water and Hydraulics Structures Irrigation and Hydraulics , Ain Shams University	…….
Prof. Dr. Iman Mahmoud Elazizy Prof. of Hydraulics and Water Resources Irrigation and Hydraulics , Ain Shams University	…….

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Date:25 May 2016

Statement

This Thesis is Submitted as a Partial Fulfilment of Doctor of Philosophy in Civil Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Rasha Hosny Abd El Monem

Signature

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Date:25 May 2016

Researcher Data

Name	: Rasha Hosny Abd El Monem
Date of birth	: 2nd of April 1981
Place of birth	: Cairo
Last academic degree	: Master of Science,
Field of specialization	: Public Work
University issued the degree	: Ain Shams University
Date of issued degree	: 14/7/2011
Current job	: Water Resource Engineering

Thesis Summary

The River Nile is the longest river in the world, its length from its remote sources to its mouth on the Mediterranean Sea is about 6800 km, it considered as the father of African rivers and one of the major basins in the world. Its catchment covers approximately 10% of the African continent, with an area of 3.11 million km², it extends from 4^{o} S to 31 N^{o} latitude and from about 21^{o} 30/ E to 40^{o} 30/ E longitude, and spreads over eleven countries namely: Burundi, Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, South Sudan, Tanzania, and Uganda. The total length of the river and its tributaries amount to some 37,205 km, its main lakes areas total 81,550 km^2 and its swamps areas total of some 69,720 km^2.

The River Nile is distinguished from other great rivers of the world by the fact that half of its course flows through countries with no effective rainfall. Almost all the water of the Nile is generated on an area covering only 20 percent of the basin, while the rest is in arid or semi-arid regions where the rainfall is minimal and where evaporation and seepage losses are very large.

Also the Nile River is subject to political interactions. The modern history of hydro-politics in the Nile basin is very complex and has wide consequences both for regional and global developments. It is increasingly recognized that appropriate water resources planning and management at a river basin level is viable only by considering the complete water cycle in the basin.

This research aims to find the best approach for managing the Eastern Nile Region through investigating the impacts of the different development scenarios using Mathematical Models and selecting the optimum solution that maximize the benefits and minimize the negative impacts on a regional scale. This methodology would be applied at sub-basins Level, which will help the decision makers to select the most suitable development plans.

In order to obtain this aim, the WEAP (Water Evaluation and planning) model has been used. WEAP is a planning tool to evaluate the sustainability of existing water demand and supply patterns and exploring unconventional long-range scenarios. The schematization of Atbara Basin has been built from scratch using

WEAP model to simulate the behavior of the basin when the development projects in Ethiopia and Sudan take place. The schematization for Atbara Basin has been created and the basin has been divided into 10 subbasins according to the development projects in the basin, to make a Sub-Basin for each dam. The calibration tests provided a good result, as the RMSE was with an average value of 0.8. The verification take place for a period form 1975 till 2012 and the results show a good simulation of the Atbara Model.

In order to study and assess Atbara Basin, 18 scenarios, including zero scenario and a baseline scenario, have been set to address the potential projects which are proposed in the basin and determine its potential impacts on the basin. Four proposed dams in Ethiopia and Sudan have been selected to be studied and in addition to the agricultural projects of a total area of 461,684 feddans (170,542 feddans in Ethiopia and 291,142 feddans in Sudan). These 18 scenarios have been divided into 3 main categories according to the probable implementation period: short, medium, and long term scenarios. Each category is divided into three scenarios according to the priority of each project. To determine the optimum scenario for developing the basin, a comparison between these scenarios outputs has been made. A screening has been made before the comparison, some scenarios has been neglected due to its unlogical results.

The implementation of Sudan projects, irrigation and hydropower, (short term impact) will cause an average flow reduction of about 2 BCM annually. In the same time, it will not affect the monthly flow pattern so it will not increase the flow in dry months.

And when Sudan projects are implemented together with hydropower projects in Ethiopia the results shows that these projects will cause an average annual reduction of about 2.4 BCM of Atbara Basin outflow. Also it will cause a noticed effect on the flow pattern of the Basin, as the outflow is continuous all over the year but with a reduction ranging from 1.9 to 2.7 BCM in July and August but it increases for the remaining months with a range from 0.2 to 0.6 BCM.

For long term impact scenarios, irrigation projects in Sudan and Ethiopia with the total area of 461,682 feddans will be implemented beside other projects. These projects will reduce the contribution of Atbara Basin to the Nile Basin System due

to its consumption. Water availability during drought periods will depend entirely on the release policy of the dams and the consumption of irrigation projects.
The cascading effect when all hydropower projects in Ethiopia and Sudan go into operation together with potential irrigated areas for both Ethiopia and Sudan will have a total consumption of about 2.1, 3 BCM respectively, this amount represents half the mean annual flow of the Atbara Basin. The situation is most severe if these development projects occur with dry period, since it may result in consuming almost the total yield of Atbara basin.

It was recommended that In order to sustain and maximize the outflow of Atbara Basin, the basin has to operate for hydropower projects only and if there will be irrigation it has to be with smaller areas, this is due to many reasons especially the topography and the climate of the basin. These two reasons make the parts of high rate of rainfall has the most difficult topology where there can't be cultivate, and vise verse.

Development in Ethiopia if divided between other river basins especially Baro - Akobo which has hydropower and agriculture potential as well as water conservation potential would be better from Egyptian water resources point of view. Also, Agriculture development in Sudan would be better for Egypt if it depends on rainfed agriculture areas.
Key words:
River Nile, Atbara Basin, Management, Development projects

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