NILE BASIN INITIATIVE

Eastern Nile Subsidiary Action Program

EASTERN NILE TECHNICAL REGIONAL OFFICE (ENTRO)

EASTERN NILE MULTI-SECTORAL INVESTMENT OPPORTUNITY ANALYSIS

Multi-Sectoral Analysis of Investment Opportunities Report

December 2014

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ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
AHD	Aswan High Dam
BCM	Billion Cubic Meter
BSG	Benishangul Gumuz Region
CC	Country Consultation
COMESA	Common Market for Eastern and Southern Africa
CRA	Cooperative Regional Assessment
CRGE	Climate Resilient Green Economy
EAC	East African Community
ECCAS	Economic Community of Central African States
ECGLC	Economic Community of the Great Lakes Countries
EEPCO	Ethiopian Electric Power Corporation
EIA	Environmental Impact Assessment
ENID	Eastern Nile Irrigation and Drainage
ENCOM	Eastern Nile Committee Of Ministers
ENIMIS	Establishment of Eastern Nile Irrigation Management Information System
ENPT	Eastern Nile Power Trade
ENSAP	Eastern Nile Subsidiary Action Plan
ENSAPT	Eastern Nile Subsidiary Action Plan Team
ENTRO	Eastern Nile Technical Regional Office (NBI)
EWUAP	Efficient Water Use for Agricultural Production
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GERD	Grand Ethiopian Renaissance Dam
GIS	Geographic Information System
GWh/y	GigaWatt hour/year
HCENR	Higher Council for Environmental and Natural Resources
HDI	Human Development Indices
HSU	Hydrological Similar Units
IDEN	Integrated Development of Eastern Nile
IGAD	Inter-Governmental Authority on Development
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISAP	Integrated Strategic Action Plan
IUCN	International Union for Conservation of Nature and Natural Resources
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
JMP	Joint Multipurpose Project
MCA	Multi Criteria Analysis
MEDIWR	Ministry of Electricity, Dams, Irrigation and Water Resources
MoE	Ministry of Environment
MoWI	Ministry of Water and Irrigation
MSIOA	Multi Sector Investment Opportunity Analysis
MW	Mega Watt

NBI	Nile Basin Initiative
NCORE	Nile Cooperation for result project
NELCOM	Nile Equatorial Lakes Council of Ministers
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELSAP-CU	NELSAP Coordination Unit
NELTAC Nile	Nile Equatorial Lakes Technical Advisory Committee
NGO	Non-Governmental Organization
NIB	National Irrigation Board
Nile-COM	Nile Council of Ministers
NWRMS	National Water Resources Management Strategy
OMM	Operation, Maintenance and Management
PMU	Project Management Unit
PRSP	Poverty Reduction Strategy Program
RATP	Regional Agricultural Trade and Productivity Project
RPSC	Regional Project Steering Committee
RSS	Republic of South Sudan
SAP	Subsidiary Action Program
SVP	Shared Vision Program
UNDP	United Nations Development Program
WB	World Bank
WRMA	Water Resources Management Authority
WRMD	Water Resources Management and Development
WSTF	Water Services Trust Fund
WUA	Water Users Association

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1. Introduction and Background

1.1 Nile Basin Initiative (NBI)

Cooperative water resources management is complex in any international river basin. In the Nile River basin, which is characterized by water scarcity, poverty, a long history of dispute and insecurity, and rapidly growing populations and demand for water, it is particularly challenging.

In February 1999, the Nile Council of Ministers of Water Resources (Nile-COM), of the Nile River basin riparian States, took the decision to establish the NBI as a transitional arrangement. The NBI shared vision is set out in its Strategic Action Program: "*to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources*". This vision and the objectives of the MSOIA are clearly strongly related.

The Strategic Action Program also set out some specific objectives for the NBI:

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

It also mandated the creation of implementation programs: the Shared Vision Program (SVP) to build support and capacity for cooperation, and two Subsidiary Action Programs (SAPs) to promote cooperative investment and prepare regional trans-boundary investments. This initial institutional architecture has guided NBI development for more than a decade

The two sub-regional Subsidiary Action Programs (SAPs) are: the Eastern Nile Subsidiary Action Program (ENSAP) and the Nile Equatorial Lakes (NEL) Subsidiary Action Program (NELSAP).

1.2 ENSAP

The Eastern Nile Subsidiary Action Program (ENSAP) of the NBI was launched by Egypt, Ethiopia and the Sudan (with South Sudan joining in 2012) to initiate concrete joint investments and action on the ground in the Eastern Nile sub-basin in the areas of power generation and interconnection, irrigation and drainage, flood preparedness and early warning, watershed management, development of planning models and joint multipurpose programs. ENSAP is governed by the Eastern Nile Council of Ministers (ENCOM) and implemented by the Eastern Nile Technical Regional Office (ENTRO) in Addis Ababa, Ethiopia. Funding for ENSAP accrues from Eastern Nile countries and varied bilateral and multilateral development partners.

The Integrated Development of the Eastern Nile (IDEN), the first ENSAP project, was agreed in 2002 with a first set of seven sub-projects aimed at tangible win-win gains in the areas of watershed management, flood preparedness, early warning and response, irrigation and drainage, power supply interconnection and regional power trade and later the Joint Multipurpose Program [JMP]. Some of these projects have successfully completed their preparations, and are advancing to implementation.

1.3 NCORE

To consolidate the gains from the first round of ENSAP investment projects, ENTRO together with the other NBI centres received funding from the Nile Basin Trust Fund/Cooperation in International Waters in Africa entitled Nile Cooperation for Results Project (NCORE). supporting the three NBI centres – the Nile-SEC, NELSAP-CU and ENTRO.

The development objective of the NCORE is "to facilitate cooperative water resource management and development in the Nile Basin." This would be achieved through the provision of targeted technical assistance to the NBI member countries and broader stakeholders, to facilitate cooperative activities, improve integrated water resources planning and management, and identify and prepare studies of potential investments of regional significance.

The Project comprises the following three components:

- Component 1: Advancing Nile Basin-Wide Cooperation and Analysis: This Component will support activities at the NBI Secretariat related to its core functions of Facilitating Cooperation and Water Resource Management
- Component 2: Promotion of Sustainable Development and Planning in the Nile Equatorial Lakes Region: This will support the NBI in its efforts to advance investment opportunities in the Nile Equatorial Lakes region
- Component 3: Promotion of Sustainable Development and Planning in the Eastern Nile Region: This Component will support NBI in promoting cooperative activities, water resource management and sustainable development in the Eastern Nile.

Component 3, for ENTRO, will support results related to its core function under two sub-programs:

- The first provides a foundation for improved understanding of issues specific to the Eastern Nile sub-basin and aims to improve public domain access to the Eastern Nile knowledge base while
- The second promotes holistic approaches to preparing and operating water investments, to better take into consideration and communicate environmental and social issues.

1.4 The Eastern Nile MSOIA

1.4.1 Overview and Rationale

The EN-MSIOA study is one of several specific studies that is being undertaken to achieve the general objective of the NCORE from the Eastern Nile perspective.

Rapid Population growth, severe land degradation, and lack of adequate storage infrastructure are among the key challenges that hindered development in the Eastern Nile (EN).

The findings of the Cooperative Regional Assessment studies conducted by ENTRO for the ENSAP Projects reveals the followings:

- Unilateral, uncoordinated planning of expansions and Lack of "no-borders" analysis /basin-wide perspective for irrigation development in the EN could lead to Water Conflict in the EN Region. The projected water requirement per EN country master plans is estimated to be 108 BCM/Year.
- The EN region has huge untapped Hydropower potential. There is a need for a coordinated investment plan in power trade
- Through the Cooperative Regional Assessment (CRA), Power generation and interconnection, irrigation and drainage, watershed management as well as the Joint Multi-purpose Project have provided valuable information. However, the assessments have not been carried out from the wider basin resource optimization and efficiency considerations.

A multi sector investment opportunity assessment (MSIOA) is thus needed to identify a coordinated water infrastructure investment strategy for the EN, comprised of prioritized water-related investments (regional or national with regional significance), that promotes shared, sustainable economic growth and development in the EN region.

The overall objective is to develop a regional water investment strategy for the EN region that broadly supports socio-economic development, poverty reduction, and the reversal of environmental degradation.

The EN-MSIOA study is being carried out over a 12 months and in addition the already Inception Phase (Task 0) has been divided into four (4) main tasks:

- Task 1: Inventory and Situation Analysis;
- Task 2: Strategic Scoping of EN Multi-Sectoral Investments;
- **Task 3: Multi-Sectoral Analysis of Investment Opportunities;**
- Task 4: MSIOA Final Products.

1.4.2 Multi-Sectoral Analysis of Investment Opportunities (Task 3)

This report is mainly focussed on presenting the analytical framework deveopped and the results of its application to carry out a multi-sectoral analysis of investment opportunities in the EN basin.

The report contains the following chapters

- Chapter 1 briefly presents some context on the EN region, and the MSIOA in order to fully appreciate the objectives of this study. The place of this study within the context of ENSAP initiatives, especially the WRD project, is outlined and finally the place of this report within the overall study is presented.
- A key part of MSIOA has been the development of an analytical framework in consultation with ENTRO. Chapter 2 presents this analytical framework and is critical in that the conclusions of this report and the study as a whole will depend heavily on this framework. The analytical framework includes two core components, the EN Basin Simulation Model (ENBSM) and the multi-criteria analysis (MCA). The ENBSM produces both water resources-related and socio-economic outputs which can then be used together with other indicators in the MCA.
- Chapter 3 presents the results of applying the analytical framework to different water resources management and development scenarios.
- Chapter 4 makes a preliminary assessment of water resources investment options with the aim of prioritising investments and developing a sequential investment plan. Investment and financing options are considered.

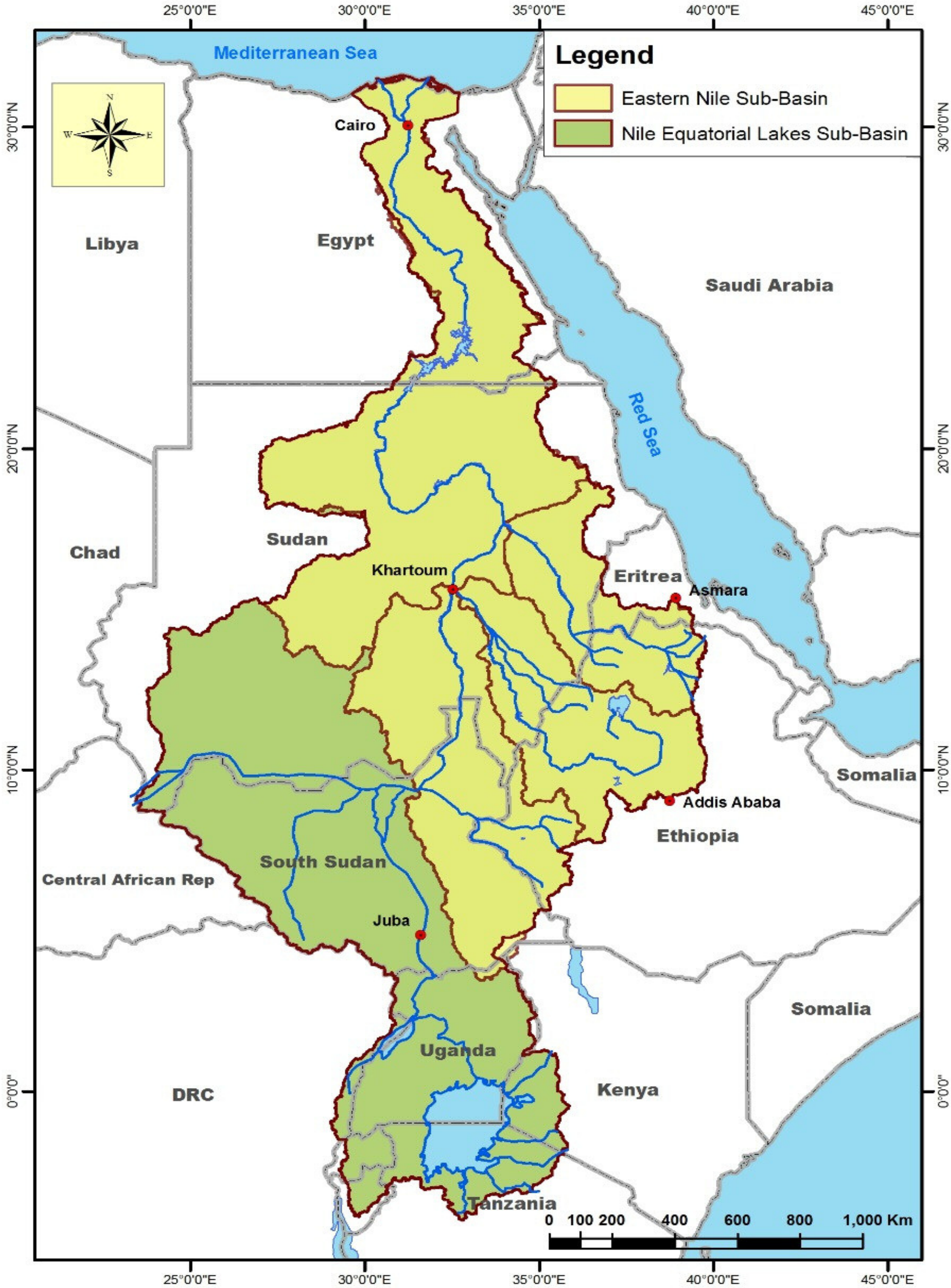


Figure 1-1 : The EN region within the Nile River basin.

2. Development of the Analytical Framework

2.1 INTRODUCTION

The Sector-based Cooperation Regional Assessment (CRA) for: (a) EN Power Trade and Power Interconnection; (b) EN Irrigation and drainage study; and (c) EN Watershed Management provide the project baseline for the subject study. These studies, together with the Situational Assessment informed the scoping report (Task 2) in its identification of regionallyu significant projects.

The data, information and knowledge generated from these studies were mainstreamed as part of the Central EN knowledge base developed under the EN Planning Model Project (ENPM). In additional a number of analytical tools were developed under the ENPM to facilitate the process of informed decision making in the region. Among these are a suite of simulation, optimization and multi-criteria analysis tools.

In the Situational Analysis (Task 1 report) the status of ENTRO Knowledge base together with potential development investments in each sectors were identified. These include both the identification of potential on a sub-basin and national basis and of individual projects. These included both sectoral development projects and multipurpose projects (MPP).

While almost all of the potential development could be considered useful, with the potential to contribute to economic development and poverty reduction, it is clearly unrealistic to consider developing them all simultaneously. Within some of the sectors, the energy sector in particular, efforts on a transboundary basis have already been made to prioritize projects in cognizance of both regional and national needs. In other sectors, some prioritization has been carried out but mainly at the national levels. There is an **absence, however, of a regional level prioritization** (and associated sequencing) of water resources management and development projects taking into account all sectors. There is also an **absence of a region-wide assessment of what can realistically be developed using the available resources**, including in particular the water resources of the EN region. It is clearly likely that there may be some competition for water resources and there is a need to understand where the issues are and whether there are parts of the basin where competition for water may become a real challenge in the future. In view of the fact that the development of any sector will place a demand both on financial and natural resources, it is important to choose carefully and there is clearly the implication that investments cannot only be compared with other investments within the same sector, but also with the level of investment in other sectors.

In this Chapter, a framework for the analysis of potential investment projects is developed. This analytical framework is at the core not only of this report but also of the MSOIA as a whole.

There are two key elements of the analytical framework:

- The EN Basin water distribution and Mass Balance Analysis,
- Economic Analysis.

These models are linked within the analytical framework. Much of the economic evaluation depends on the outputs of the water distribution model.

It should be stressed that the aim of the analytical framework is not to evaluate individual projects. Indeed, it is exactly this fact which sets this study apart from conventional single project economic or feasibility models of analysis. The **analytical framework has been designed to look at the overall impacts of different combinations of water resources management and development trajectories in different sectors in the different sub-basins**. These impacts include the impacts on water resources (availability), on poverty reduction (economic returns, employment creation) and on the social and biophysical environments.

The aim therefore of the EN MSOIA is **primarily to analyse the economic benefits of different multi-sector water resources management and development scenarios** as represented by the combination of different development levels in each sector in different parts of the basin. This analysis notably includes the analysis of the impacts of certain "constraints" such as the maintenance of environmental flows, climate change and those resulting from the e trans boundary nature of the system.

In the final step of the study, the most favourable water resources management and development scenarios will be used to develop an investment strategy and associated action plan comprising, where possible, identification of the necessary projects and programmers.

2.2 DEVELOPMENT LEVELS / SCENARIOS / PROSPECTIVE SCENARIOS

As the use of the word "scenario" may be confusing, the Consultant proposes the following terminology for the present and coming MSIOA reports:

- For one given water related sector (e.g. *energy* or irrigation), the development levels represent the possible future levels of development of the sector.
- A combination of possible future development levels of different water related sectors is called a "water resources management and development scenario", or simply a "scenario".
- However, a "prospective scenario" is the result of a prospective exercise taking into account external factors. A prospective scenario will probably include a water resources management and development scenario, but will also be associated with a regional context.

In the present report, only development levels and water resources management and development scenarios have been analyzed. The implications will be taken further in the next report (investment strategy and action plan).

2.3 THE EN BASIN SIMULATION MODEL

2.3.1 Objectives OF THE Model

The general objective of the EN Basin simulation Model is to support strategic planning decisions at the scale of the EN region, through assisting to foresee the impacts of future possible water resources management and development scenarios in the EN region.

The specific objectives of the EN Basin Simulation Model are to model:

- the functioning of the EN region hydrological systems, including natural and man-made reservoirs, wetlands, irrigation and hydropower schemes in the EN river systems and its main tributaries.

- the satisfaction of the water demand, under different water resources management and development scenarios, including different development levels of:
  - irrigation water demand,
  - hydropower water demand,
  - water storage operations,
  - environmental flows requirements.

2.3.2 Model Setup

The EN Basin Planning Model is a water distribution model, distributing water through the main branches of the EN region water system, on a monthly basis, over the period 1900-2002. Because the time of concentration of the water in the river is less than one month in the various branches, no river routing has been used. Propagation delays only occur because of the surface water reservoirs which are used to simulate natural and manmade reservoirs as well as significant wetlands.

The extent of the analysis includes the 4 EN Sub-basins from their headwaters in the Ethiopian highlands up to the Mediterranean sea.

The key characteristics of the model can be summarized as follows:

- total of 52 demand nodes were incorporated to model both existing and potential future water abstractions;
- 2 wetlands and spill flows were modelled being the Machar Marshes and Tawlor spills in the Baro-Akobo-Sobat-Pibor river system;
- A total of 30 reservoir nodes were incorporated for modelling both existing and potential water storage infrastructure in the basin.

The schematics of the EN Basin Planning Model as it has been elaborated under MIKEHydro, are provided in Annex D of this report. . For illustration purposes Figure 2-1 overleaf shows an extract from the schematic of the Baro-Akobo-Sobat Sub-basin.

2.3.3 Model Input

As shown overleaf in the configured EN Basin Planning Model also allows the modelling of many hydropower and irrigation schemes, including water storage reservoirs. Model inputs include:

- catchment inflows,
- potable water demand,
- irrigation water demand,
- water storage required for the satisfaction of the downstream water demand,
- environmental flow requirement downstream any abstraction or storage nodes,
- lakes and reservoirs characteristics and operation rules (if any),
- Hydropower plants characteristics.

The model receives as an input the following time series and data sets:

- Monthly historical time series records for incremental catchment flows over the period (1900-2002);,
- Average monthly demands for all water abstraction nodes;

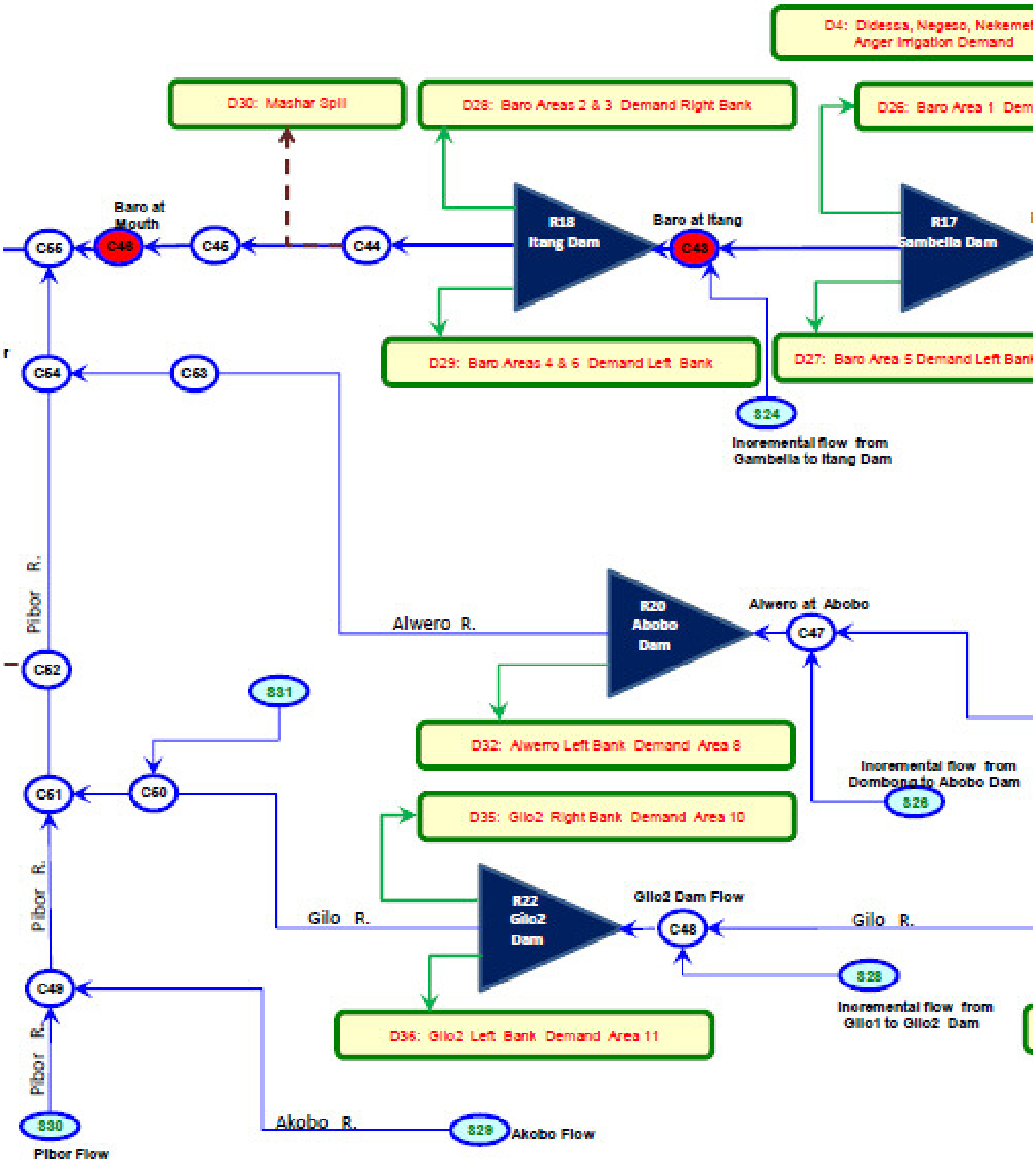


Figure 2-1: Extract from schematic of the Baro-Akobo-Sobat Sub-basin

- Reservoir characteristics data which include the following:
  - Stage-Volume-Area characteristics for each reservoir,
  - Average monthly rainfall and evaporation data for each reservoir;
  - Hydropower plant and Turbine characteristics for each reservoir;
  - Operation rules for existing reservoir which include the monthly guide curve of reservoir water levels and/or reservoir releases;
  - Environmental flow requirements which set the minimum flow releases for each reservoir and target releases against certain demands downstream;
- Average monthly Environmental flow requirement for set of control nodes downstream,

The density of nodes in as shown in Annex D represents the level of detail of the model. It is quite clear that if one looks at a specific small sub-basin (e.g. Khor Gila and Pibor River basin), the level of detail is very limited: one catchment inflow, possibility to consider one irrigation water demand with associated storage, possibility to consider a downstream hydropower scheme, possibility to consider one downstream environmental flow requirement. Therefore, it is worth stressing the fact that the EN Basin Planning Model should **not be used for modelling complex water systems at the local level** since it is designed for this purpose, but only for the purpose of analysis at the scale of the entire EN region.

2.3.4 Model Output

For the present EN MSIOA, the EN Basin Planning Model provides two outputs:

- to feed the simple annual water balance model and the economic assessment model (see Section **Error! Reference source not found.**), for the economic analysis of different combinations of water management and development activities,
- to show key characteristics of the EN water system under different combinations of water management and development activities.

An Excel Based Annual water balance and economic Analysis tool was developed to study (see Section 2.4) the implication of different scenarios on water availability and for economic valuation of each scenario. The annual water balance and economic analysis receives the following outputs from the Water System Simulation Model:

- Simulated average annual flows for all nodes under each scenario;
- Simulated annual evaporation losses from each reservoir;
- Simulated monthly water uses for each abstraction node;
- Average annual energy production for all the hydropower plants (to be used for energy costing),
- Average surface area of the main water bodies (to be used for fisheries and environmental costing),
- Irrigated area satisfied in 4 out of 5 years (80% assurance) (to be used for irrigation costing) for the various sub-basins as well as for different sections of the Nile River itself,
- Water storage capacity required for the satisfaction of the potable water, irrigation water and environmental water requirements, for the various sub-basins as well as for different sections of the Nile River itself.

2.3.5 Model Performance

Validation was carried out by comparing the observed flows with outputs of Mike Hydro models at the selected stations of *Jebiaulia, Elgibra, Border, Khartoum and High Aswan Dam* inflow. To facilitate the evaluation, visual as well as statistical comparison was carried out. Statistical parameters such as use of Nash-Sutcliffe Efficiency (NSE), Coefficient of determination (R2), Mean Relative bias (PBAIS) and Root Mean Square error (RSR) were used. The visual comparisons of the simulated and observed flows at selected sites of eastern Nile are shown in .

The simulated flow has been plotted against the observed flow for the validation periods. There is a good agreement between simulated and observed monthly flows. The low flows are quite well represented and there is good overall agreement in the shape of the hydrograph. In the context of low flow, the observed and simulated flow matched each other well. The model has simulated the behavior of the observed flow during the validation period. The rising and falling limbs have been captured.

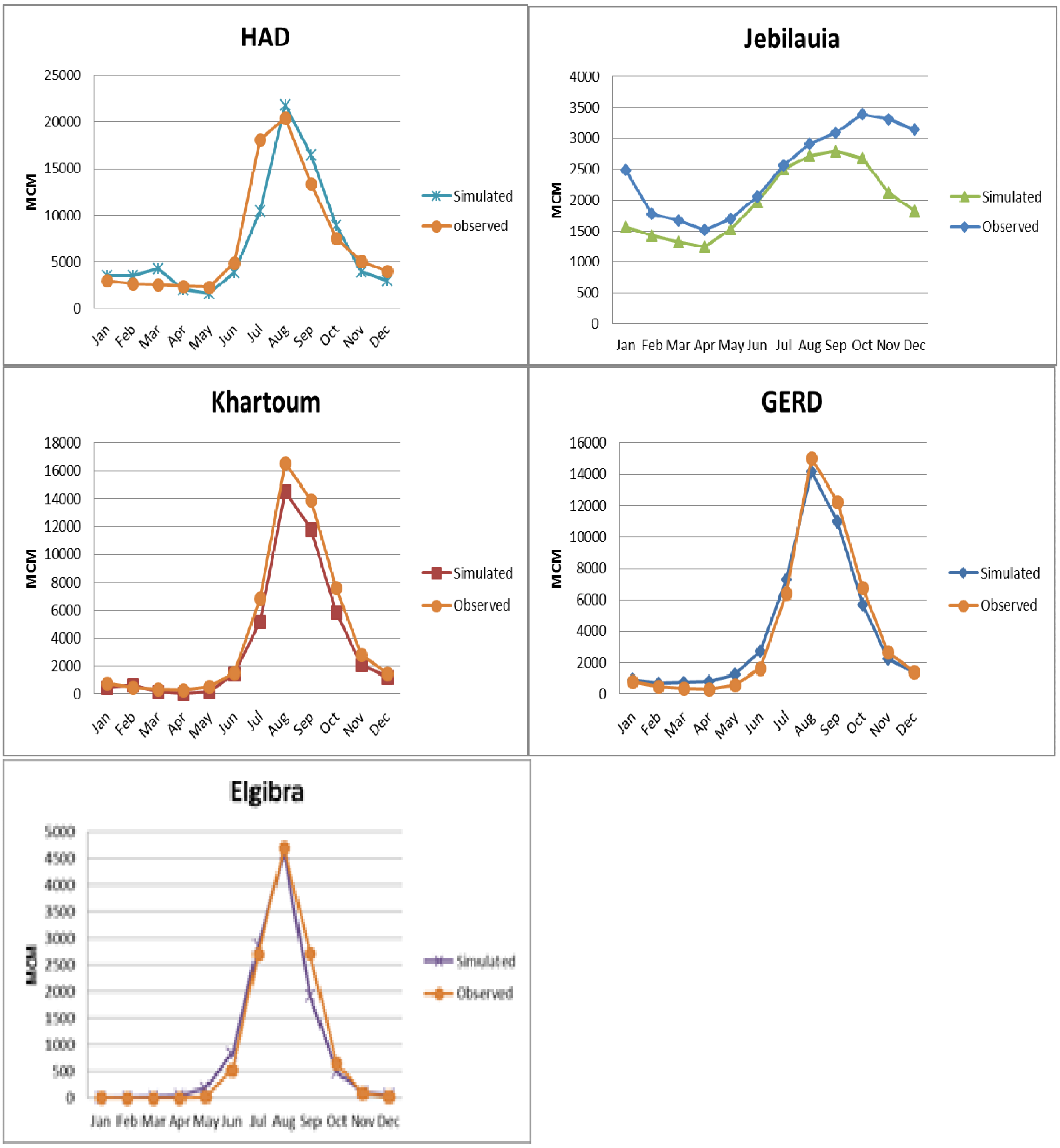


Figure 2-2 : Comparision of Mean monthly flows (simulated and observed) at key points

2.4 THE ANNUAL WATER BALANCE AND ECONOMIC ASSESSMENT TOOL

2.4.1 Introduction

The annual water balance and economic assessment model is the other tool at the heart of the analytical framework. Such a tool provides the following:

- Detailed annual water balance analysis to study the implications of different scenarios on water availability at each node in the system;
- The Economic Assessment tool to assess from an economic point of view the multisector development opportunities in the EN region provides a unique knowledge base for the EN MSIOA Project. It includes the following:
    - Detailed project database and description for all existing and potential investment schemes. This include infrastructure, scheme operation and productivity, historical water abstractions and economic viability of the scheme.
    - Updates of unit rates for potential irrigable projects in Egypt, Sudan and South Sudan. In the case of Ethiopia the Diagnostic component of the EN Irrigation and Drainage Study provides fairly adequate and updated economic analysis of potential irrigable schemes in Ethiopia. Access to Data and information about existing and potential schemes from different sources were mainstreamed as part of the EN-MSIOA Knowledge base platform.
    - Detailed costing analysis and systematic computation procedure for evaluation of Initial Infrastructure investment costs and recurrent costs for all irrigation schemes;
    - Computations of water requirements for irrigation, livestock and feed water requirements, pumping requirements for all irrigation schemes. This includes estimates of water requirements per unit hectare, equilibrium price of water and cost of pumping per unit hectare.
    - Estimation of production costs and net revenues generated from existing and potential irrigable projects. This permit analysis of the impact of different irrigation modernization options and economic valuation of the feasibility of rehabilitating low performing irrigation projects.
    - Detailed socio-economic analysis based on consistent set of indicators for prioritizing the set of investment projects. This include the following:
        - Net Revenue Generated ;
        - Net Present Value (NPV),
        - Employment generated from each irrigation scheme;;
        - Livestock and fisheries productivity;

A detailed draft description of the Water Balance and Economic Assessment tool, how it would work, inputs required, linkages with the EN Basin Planning Model and anticipated outputs was submitted to ENTRO in December 2014 and subsequently presented at a Client/Consultant meeting. This ensured that the economic model would deliver the expected results. Potential combinations of water development activities were also discussed with ENTRO.

The aim of the Annual Water Balance and Economic Model is to assess from a water resources availability and economic point of view the multisector development opportunities in the EN region. The structural investments (mainly hydropower and irrigation investments) taken into account in the model are those already identified in the situational analysis main report and reviewed in the Scoping Report, which saw the list reduced. Added to the identified structural investments, a number of hypotheses have been taken to estimate the potential improvement in others sectors such as integrated watershed management;

fisheries, fish farming, livestock. The degrees of development assumed for each sector are detailed in Chapter 3.

The economic model is described in Sections 2.4.2 to 2.4.6. However, in order to achieve an intimate understanding of the impacts of different inputs on outputs, it is useful to develop hands-on experience on the economic model itself.

2.4.2 Description of the Tool

The economic assessment is carried out over a 30 year time period. A shorter period, such as 25 years, is considered too short to assess the benefits of major infrastructure investments such as dams. Indeed, with a time line of only 25 years, a large part of the benefits derived from these major investments would be lost and will in fact reduce automatically, because of the discounting rate and the cost benefit ratio. All the monetary data are provided in USD. The model has been built in Microsoft Excel. The Excel spread sheets file is clearly organized in order to facilitate understanding and to ensure that the economic model is a living component of the analytical framework that will be handed over to the Client at the end of the study for future application. The structure of the file is as follows:

- A "**Mainpage**" spreadsheet for testing and visualizing the results from each scenario;
- A "**Schematic**" spreadsheet. This sheet shows detailed description of the EN System, its components, and provide linkage for the EN reservoir and irrigation database as well as access to historical time series flow records at each gauging nodes in the system.
- A "**massbalance"** spreadsheet. This sheet provide detailed annual mass balance computations at each node in the sense and its interactive in the sense that Annual mass balance computation at each node will be updates with changing the selected scenario.
- A "**scenariomanage**r" spreadsheet. This sheet provide controls for the potential investment projects and their development level that the user would like to consider as part of the scenario analysis. It is on this sheet that the user can create and test new scenarios. For each of the existing and potential investment projects, A multiplier set of 4 elements is provided under each development level (CS, IS, LD, FP). These multiplier elements could either take a value of 1 or 0. By changing the value from 0 to 1 or vice-versa, this would switch the development level for that particular project on and off. Such arrangement would enable the formulation of scenarios based on different combinations of levels of development and to rank and prioritize projects based on user defined set of socio-economic indicators and/or from national country priority perspectives. Such tool could be very powerful in facilitating informed decision making and joint fact findings or negotiations around alternative development options among conflicting users and stakeholders in the basin.
- The rest of the sheets provide detailed access to the economic analysis and the database used in the EN-MSIOA Study.
- The unit rates for all irrigation projects in Sudan and Egypt were updated based on the most recent data that were available. As far as possible, the unit prices used for the various economic analyses are grouped together and made accessible for each irrigation scheme spread sheet. This include:
    - Additional value/gross margin (per type of benefit);
    - Selling prices;
    - Investment costs;
    - Labour cost;
    - Monetary rate;

Most of the figures used in the price schedule come from the literature. They can all be easily updated at any time as required and this will automatically change the result of the model through the dynamic links in place.

The methodology to set up the economic model is briefly presented in the following paragraphs.

2.4.3 Irrigation Schemes: Water Requirement Calculations

To ensure consistency with the data sets used in previous ENSAP projects, the unit rates used in the calculation of the project water requirements (m^3/ha) for the Ethiopian irrigation projects is the same as the ones used in the EN Irrigation and Drainage Study and are presented in Appendix A.1. The information is based on the calculations carried out during preparation of the Abbay Basin Master Plan (BCEOM, 1994-1997). For the Sudan projects these types of calculations were not available and therefore, a standard crop water calculator was developed and provided for each specific scheme. The calculator permits the exploration of different standard cropping patterns and crop types that are common in Sudan. The investigation of for each scheme is the water requirements presented in the specific project reports have been included in the project descriptions in Annex A.2. These figures have been used to determine the overall water requirements for Sudan. Eygpt Crop Water computations were made by disaggregating Egypt into 5 command areas. These are: Upper Egypt, Midille Egypt, East Delta, Middle Delta and West Delta. Annex A.3 provide estimate of crop water requirement per unit Feddan in each of the 5 regions together with cropping patterns.

2.4.4 Irrigation Schemes: Costing

Costing of irrigation schemes was based on three components:

- **Estimate of initial infrastructure investment cost**. This is based on secondary data obtained from most recent documents. The main source of costing data for Egypt irrigation projects were extracted from the World Bank Project Appraisal Document for West Delta Project. Detailed break down of the initial Infrastructure investment cost per unit feddan is provided in Annex B.1. For Ethiopia Irrigation Project, detailed estimates of unit rates and costing of irrigation projects has been recently updated as part of the diagnostic component of the ENIDS. Hence to maintain consistency and avoid duplication of efforts the costing of irrigation schemes in Ethiopia was based on the estimates provided as part of the ENIDS project. For the case of Sudan, it was realized that the unit rates adopted in the ENIDS study were outdated and need revision. Hence resort was made to update the unit rates based on consultation with the relevant agencies and Ministry Staff in Sudan as well as secondary data collected from different sources. One of the main source of information for costing irrigation projects in Sudan is the feasibility study report entitled "*SUDAN AGRO-INDUSTRY INVESTMENT OPPORTUNITY*" prepared by the Sudan Federal Ministry of Agriculture. Detailed breakdown of unit cost estimate for initial infrastructure investment per Feddan in Sudan is provided in Annex B.1.
- **Estimate of Recurrent Cost**. Standard Excel calculator is developed to estimate the energy requirements and cost of pumping. To maintain consistency and to provide a fair background for comparing projects, the standard maintenance rates used in estimating the recurrent cost for Ethiopia projects under the ENIDS Study were adopted for the Case of Egypt, Sudan and Sudan Sudan maintenance of irrigation schemes. Detailed breakdown for estimate of recurrent costs and pumping requirements were provided in Annex B.2.

2.4.5 Economic Analysis

- Detailed Economic analysis has only been carried out for Sudan, South Sudan and Egypt irrigation investments (for new development, irrigation modernization and investments on rehabilitating existing schemes).
- The economic analysis for Ethiopia irrigation project has been recently updated under the ENIDS Study. Values of EIRR, NPV and B/C ratio for each project were extracted from the ENIDS study.
- The economic analysis for large scale hydropower schemes in Ethiopia and Sudan has been conducted under the EN Power Trade Study and recently updated through a number of feasibility and pre-feasibility studies. Hence Values of EIRR, NPV and B/C for hydropower projects were extracted from the Site Specific feasibility studies for these projects.
- Standard templates were constructed to evaluate unit cost of productions of irrigation schemes, the net revenue generated per unit hectare and to perform the cost benefit analysis. Annex C presents supporting information's.

2.4.6 Output of the economic model

As poverty reduction is a key objective of ENSAP and its Member States, it is proposed to analyse for each scenario the:

- **Economic Net Present Value (NPV**) and Economic Internal Rate of Return (EIRR). For each of the combinations, the NPV and EIRR are provided.
- **Output employment**: This presents an estimate of the generation of employment per country and per sub-basin for each combination of water development activities. The hypothesis used to estimate the employment generated are shown in the following table:

Table 2-1: Hypothesis on employment

Field	Unit	Direct Employment
Irrigation Egypt:	Employment/Ha	17.857
Irrigation Ethiopia	Employment/Ha	10.714
Irrigation Sudan	Employment/Ha	5.000
Irrigation S.Sudan	Employment/Ha	4.770
Hydropower	Full time jobs/GWh	0.200
Livestock ownership	TLU/Person	5.190
Fisheriesl	Tons of fish/year/fisherman	3.000
Other (construction; operation; etc.)	% of total Employments	20%

2.5 MULTI-CRITERIA ANALYSIS (MCA)

2.5.1 Introduction

The Multi-criteria analysis will be used to make a comparative evaluation of the scenarios evaluated using the EN Basin Simulation Model as already introduced earlier in this chapter. This comparative evaluation should allow the discarding of some scenarios and the ranking of the remainder in terms of how they meet the water resources developments and management expectations of the Eastern Nile countries.

In the rest of this section of the report the MCA is introduced, described and details of how it will be applied, presented.

2.5.2 Multi-criteria analysis methodology

Multi-criteria analysis is a well-accepted approach to the analysis of choices/options when this cannot be done in using standard statistical methods or other approaches. As its names implies, MCA allows the use of a range of often quite different criteria to be used to evaluate options, in this case a number of water resources development and management scenarios. These criteria should obviously reflect the key management and development issues that are the focus of the scenarios and there has to be some way of measuring the criteria or the degree to which they are met/satisfied. This is done through the use of "indicators". Indicators should be measurable otherwise it is difficult[1] to use them in the MCA.

A challenge facing the application of MCA and its use of a wide range of criteria covering different thematics, is that these thematics may have relatively greater or lesser significance in terms of the choices or options being analyzed. The address this challenge, the different criteria can be assigned different weights.

The steps, therefore in developing and applying the MCA can be summarized as follows:

a) Setting the objective of the MCA

b) Selection of the evaluation criteria and indicators

c) Normalisation of the indicators

d) Weighting of the indicators

2.5.3 Objective

The objective of this MCA is to evaluate a number of water resources management and development scenarios in terms of how they meet the sustainable development expectations of the Eastern Nile riparian countries.

[1] Indicators can take the form of qualitative of comparative statements or rankings, but these have to be translated into numbers for the MCA.

2.5.4 Selection of criteria and indicators

The selection of criteria was stakeholder-driven. After presentation of the methodology, guidelines and some examples, stakeholders[2] representing both the necessary thematic areas and Ethiopia, South Sudan and Sudan, were given the task of proposing appropriate criteria and to look at their potential relative importance (weighting)

Five types of criteria were broadly agreed into five groups (economic, social, environmental, equity and general):

- **Economic criteria**

  The Net Present Value (in millions USD) measures the revenues generated from the hydropower, the irrigation schemes, the fisheries and the livestocks. These revenues are discounted to their present value using a discounting rate of 8%.

  We have separate the **NPV indicator into 2 dimensions**, the NPV generated from the **hydropower sector** from the NPV generated from **irrigation**. The latter is linked to the fisheries and the livestock sector. This second indicator could be interpreted as a proxy for food security, poverty alleviation and rural development since for all four countries, a major driver of growth economic is the agricultural sector.

  The **water productivity** in the irrigation sector (USD per ha) reflects the efficiency of the water uses in the agricultural sector. This indicator highlights the comparative advantages of areas and countries in terms of crop production.

- **Social indicators**

  "Empl" (total number of employs created) measures the employment generated by each scenario. These jobs are especially related to the irrigation sector, the fisheries sector and the livestock sector. It is an important social indicator since it is a proxy of poverty reduction

  Restl (total number) measure the number of people needed to be resettled by a project. This indicator is a proxy of the social damage generated by a project.

- **Environment**

  BCM-Eg (Annual BCM) is the annual flow that reaches the delta of the Nile basin in Egypt. The indicator highlight the impacts of the projects on the regional water balance. Negative value for this indicator should be interpreted as water abstractions exceeding the minimum of the environmental flows.

  MF-HAS (????) is the impact on the Minimum Environmental Flows in Sensitive Areas and/or specific points in the system. This indicator reflects the environmental impacts associated with both hydropower and irrigation infrastrucrure projects.

  Ter-Ecol (in ha) represents the total surface of land lost to reservoirs.. This indicator could be a proxy of the biodiversity associated with the HP project implementation.

- **Equity**

  Equity is a major criteria for this EN-MSIOA study and is very difficult to be captured in an indicator. **Equity favours cooperation** if it is captured by an indicator agreed by the stakeholders. It has been suggested and accepted by the participants during a MSIOA workshop to use the GINI index. The GINI index measures the inequality of the distribution of a variable (income, revenues, or any other variable) between people.

  The variable "***Revenue generated from water uses***" was used as the variable for the GINI index so that the GINI index takes the value of Zero when the "*Revenue generated from water uses per capita*" is perfectly equal between people and it take the value of One, when all "*Revenue generated from water uses per capita*" benefits only one country.

[2] This exercise was carried out at an ENTRO MSOIA workshop in Addis Ababa from 8 – 9 February 2015

- **General**

  Evap (total evaporation from human made reservoir) is an indicator that reflects the system wide performance.

  After analysis of the proposals, the table below summarizes the 10 evaluation criteria which have been retained and refined for analysis of the EN-MSIAO water resources development and management scenarios.

Table 2-2: Evalutaion Criteria for MCA

Criteria	Indicators
Economics	
NPV-HP	NPV of revenue generated from Hydropower
NPV-IR	NPV of revenue generated from agriculture projects
WP	Water productivity in irrigation sector
Social	
Empl	Employment
Restl	No. of Persons to be Resettled
Environment	
BCM-Eg	Annual flow in BCM-at Delta, Egypt
Ter-Ecol	Terrestrial Ecology: Total Loss (Ha) Ripiran forests, woodland, Wetland & Habitat
Equity	
Equity	Gini Index of benefit generated from water uses
General	
Evap	Total evaporation losses from réservoir

2.5.5 Normalization of the indicators

Normalisation means to rescale the numeric variable to a specific range. All indicator have been normalized so their scores range from 0 to 10, Zero reflecting the minimum value observed in the distribution and 10 the maximum value

2.5.6 Weighting of the indicators

METHODOLOGY

The next step required the stakeholders to give their preference on how to weight each indicator in order to ensure that the key criteria had the greatest importance for the comparision of scenarios.

To elicit the preference of the stakeholders, the "Pairwise Matrix Ranking" methodology was used. The pairwise ranking is a structured method for ranking a list of indicators in a priority order. Stakeholders were asked to fill the the table below, by comparing each pair of indicators in each blank cell. (see Table 2-3).

Table 2-3: Pairwise analysis

Criteria		Indicators
Economic	NPV-HP NPV-IR WP	- NPV of revenue generated from Hydropower - NPV of revenue generated from Irrigation - Water productivity in irrigation
Social	Empl Rstl	- Employment generated by the scenario (from agriclture, fisheries and livestocks) - No. of Persons to be Resettled if project implemented
Environment	BCM-Eg Ter.Ecol	- Annual flow in BCM-at Delta, Egypt - Terrestrial Ecology: Total Loss (Ha) Ripiran forests, woodland, Wetland & Habitat
Equity	Equity	- Gini Index of benefit generated from water uses
System-wide performance	Evap	- Total evaporation losses from réservoir

Instructions : For each pair of criteria write in the blank cell, the criteria you prefer

	NPV-HP	NPV-IR	WP	Empl	Rstl	BCM-Eg	Ter.Ecol	Equity	Evap
NPV-HP	x								
NPV-IR		x							
WP			x						
Empl				x					
Rstl					x				
BCM-Eg						x			
Ter.Ecol							x		
Equity								x	
Evap									x

2.5.7 Conclusions

This is the final step in the preparation of the MCA criteria to be used for the comparision of the scenario results.

2.6 Determination of Sectoral Development Levels

For each of the sectors, a limited number of development levels are proposed and will be tested in the models (EN Basin Planning Model & economic model). The following sections describe these sectoral development levels and some of the hypotheses used. Most of the conclusions shown in this section 2.6 come from the previous situational analysis main report.

The water resources management and development scenarios will be combinations of the various sectoral development levels.

2.6.1 Agricultural sector

2.6.1.1 Introduction

Irrigation is a key issue in the development of the EN region. It can increase the yield of crops, and thus farmers revenue and food availability, but can also have a negative impact on the environment through notably a reduction in the quantity of water available for other sectors.

Most of the data used in the economic model are extracted from the previous '*MSIOA Situational Analysis Report and based on the stakeholder consultation conducted during the field visits to countries and during the review workshop for the Situation Analysis Report.*'.

Four sectoral development trajectories are proposed:

- Current situation (CS): current level of development, reference situation,

- Improved situation (IS): Irrigation modernization, rehabilitation of current irrigation schemes and schemes under implementations,
- Large development irrigation (LDI): all identified projects advanced either to pre-feasibility or feasibility level are considered in addition to the existing ones,
- Potential irrigation (FDP): all irrigation potential that is either identified as part of country master plan, ENIDS and potential identified under current study.

2.6.1.2 Aligning National Country Priorities as Part of Regional Investment Planning

Egypt

For the case of Egypt and due to the absence of Egypt participation during the consultation workshop and field visit, an alternative modality to align Egypt national investment priority as part of regional investment planning is suggested. The proposed approach is based on Egypt Investment Envelope for the past 20 years (1990-2010) as shown in Table 2.2. As could be realized from the Table, Egypt investment in irrigated agriculture follows 2 tracks or trajectories. The first track is vertical expansion which is mainly rehabilitation of existing projects, irrigation modernization and introducing new farm technologies aimed to improve agriculture productivity and efficient water uses. The second track is basically horizontal expansion and development of large scale irrigation projects such as west delta irrigation. Each of these development tracks were phased into stages. These are short term which is considered IS in the subject study, medium term which is considered (LDI) in the analysis and long-term which is considered (FDP). A projection is made that Egypt will follow some trajectories of development for the next 20 years and on that basis future development

Table 2-4: Egypt Investment Envelope

Time Scale	Type of Investment (Million US$)			
	Small Scale with control	Rehabilitation of Irrigation	Large Scale	Total
Short-term	25.33	56.23	48.88	130.43
Medium-term	4.38	110.49	664.82	779.69
Long-term	4.34	3.77	38.10	46.21
Total	34.06	170.48	751.80	956.33

Sourece : FAO-AQUASAT (Sirte 2008 Conference).

Ethiopia

Aligning National country priorities in Ethiopia as part of the regional investment planning is based on previous efforts for mainstreaming Ethiopia Irrigation Master Plans in each sub-basin as part of the EN Irrigation and drainage Study as well as the JMP1 system Inventory. In addition, updates based on stakeholder discussions are also used.

Table 2-3: Egypt Investment Envelope

Time Scale	Type of Investment (Million US$)			
	Small Scale with control	Rehabilitation of Irrigation	Large Scale	Total
Short-term	206.72	50.62	279.77	537.11
Medium-term	693.72	177.34 5	434.14	6 305.20
Long-term	0.42	0.26	935.09	935.77
Total	**900.87**	**228.21**	**6 649.00**	**7 778.08**

Sourece : FAO-AQUASAT (Sirte 2008 Conference).

Table 2.3 presents a summary of Ethiopia Investment envelope during the last 10 to 15 years . Through looking at the table it can be realized that the bulk of the short-term and Medium-term investments focused on Community-based Integrated Natural Resource Management Projects while large scale investment is mainly on the hydropower sector (Tekeze US$ 414 million, Beles US$ 720 million, Halele US$ 720 million, Chemoga Yada I & II HEPP US$ 601 million, Gibe III HEPP US$ 2 119 million). Investments in irrigated agriculture amount to a total of approximately US$ 2017 million. This include Koga project (US$ 42 million irrigates 7 200 ha of land, in Abay river basin); Humera feasibility study (US$ 100 million irrigate 60 000 ha. in Tekeze river basin); Arjo-dedesa feasibility study (US$ 46 million irrigate 16 800 ha. In Abay river basin); Welkayet feasibility study (irrigate 40 000 ha.) and Tana-zuria feasibility study (irrigate 51 077 ha. in Abay river basin). In addition investment in Water Harvesting and Small–Scale Irrigation amount to US$ 1 491.0 million.

To ensure full integration of Ethiopia National irrigated agriculture priorities as part of the regional investment planning, all the identified potential irrigable areas in the 4 EN sub-basins were considered as part of the analysis. In addition the study explore the possibility of further expansion in irrigation on the Baro river upstream adura bifurication. It is realized that, the losses in Machar spill could be reduced with potential for expanding the Baro at Itang command areas with minimum adverse impact to downstream water uses. Figure 2.3 shows the correlation between the flow DS Baro at Itang dam and losses in Machar spill. It can be clearly recognized through exploring an additional 168,000 ha. As part of Baro at Itang command area, this would consume an additional annual water of about 0.40 Billion Cubic Meters which can be easily absorbed and minimize the losses in Machar Marshes. However, such proposal need to be carefully studied to investigate the impact from environmental and social perspectives.

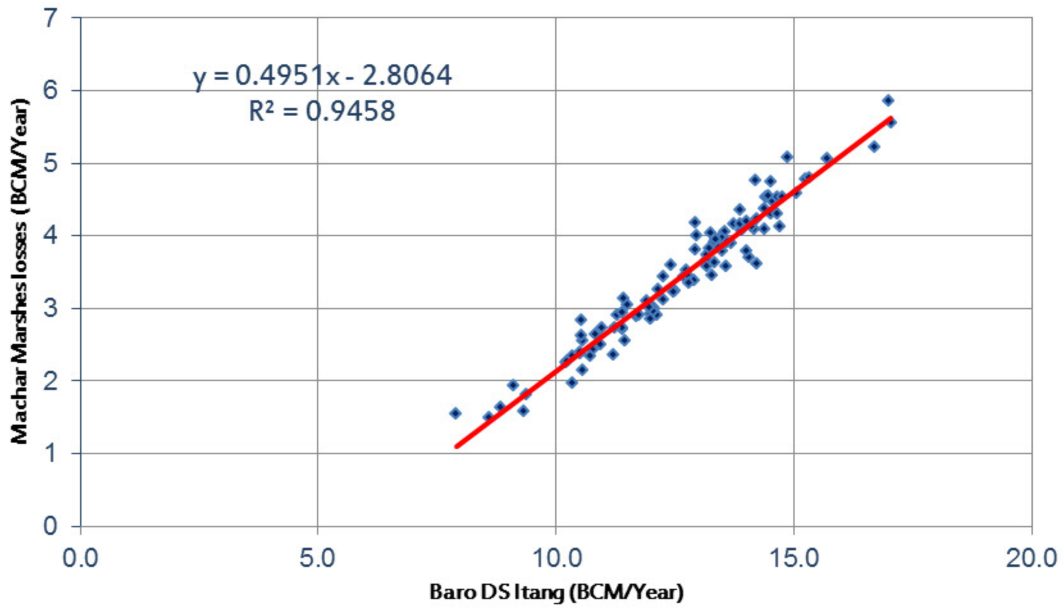


Figure 2-3 : Correlation between theBaro Annual flow DS Itang Dam and Machar Spill

South Sudan

Due to the absence of National irrigation master plan for South Sudan, reliance is made to the information that was gathered during consultation with relevant stakeholders from South Sudan during the situation analysis review workshop and also from the most recent updated information available from FAO public domain database(Table 2.4). The suitability of soils for irrigation was assessed using reference to the soil map on the basis of soil associations and related attributes available in digital format. Based on a criteria, the proportions of each soil component that meet irrigation requirements as classified below is estimated for both lowland and upland crops

- Irrigation with no constraints
- Irrigation with some constraints
- Not suitable without major improvement
- Permanently not suitable

Penman evaporation estimates along with irrigation efficiency of 50% were used to estimate the potential irrigation demand for each of the following four situations:

- Best soils for upland crops (UB)
- Best and suitable soils for upland crops (US)
- Best soils for lowland crops (LB)
- Best and suitable soils for lowland crops (LS)

Table 2-5: FAO Estimates of Irrigable Areas in BAS South Sudan

Irrigable Area (1000ha)		Potential Water Requirements (BCM)
UB	539.2	5 949
US	6 189.1	68 056
LB	2 349.1	26 054
LS	7 349.8	80 758
Total	16 427.2	180 817

From the table above, it can be clearly recognized that suitable soil and land resources are not constraint for irrigation development but water availability is a real challenge. Ti realistically explore possible irrigation potential in BAS (South Sudan), the consultant suggested the following:

- Rehabilitation of Melut Sugar project along the white Nile under IS;
- Potential of 40,000 ha to 80,000 ha rice and cereal irrigated areas on the Sobat river System between Naser and Hillet Doleib;
- Potential of 60,00 ha. to 120000 ha. Irrigated areas in the Pibor River System. It is estimated on annual basis that the Tawlor spill along the Pibor River System DS Khor Gila is about 2.4 BCM (Figure 2.4). Such losses could be minimized through exploring potential for water abstraction of about 1.0 BCM for irrigation around 100,000 ha.

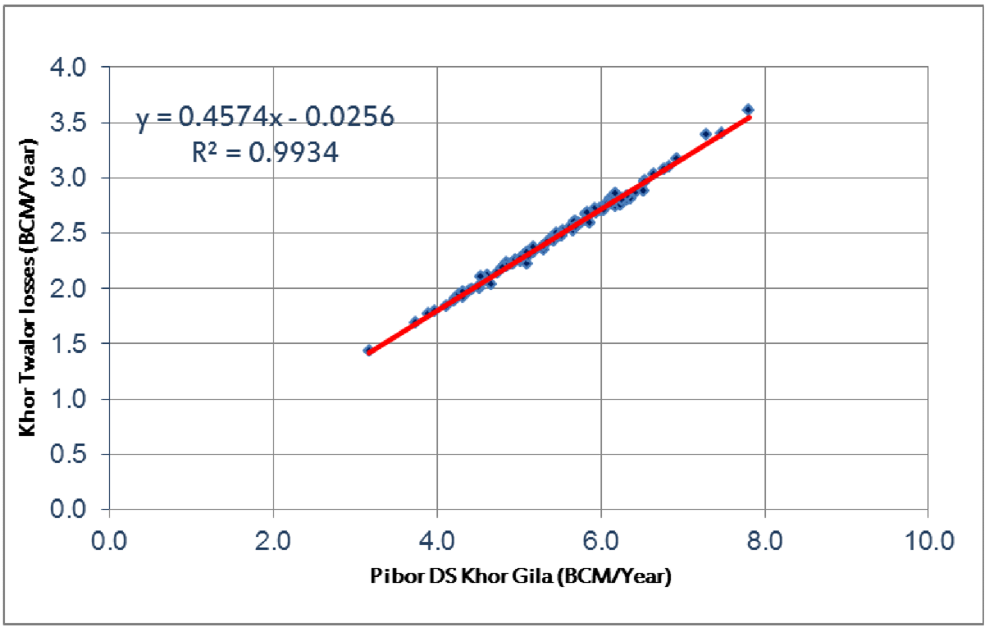


Figure 2-4: Correlation between the Pibor Annual flow DSKhor Gila and Khor Tawlor Spill

Sudan

Similar to Ethiopia, aligning Sudan national priorities as part of the regional investment planning is based on previous efforts for mainstreaming national country Irrigation Master Plans as part of the EN Irrigation and drainage Study as well as the JMP1 system Inventory. In addition consideration for recent updates is well accommodated through consultation with relevant stakeholders during both the inception phase and ield study as well as during the review of the situation analysis report.

Table 2-6 present a summary of Sudan Investment envolpe during the last 10 to 15 years . Through looking at the table it can be realized that the bulk of the short-term investments focused on rainwater harvesting and support for traditional rained agriculture in Western Sudan. The Rehabilitation of existing irrigation projects amount for about US$ 185.35 million (mainly Rahad, Hourga and Nour Ed-Din, and Gash delta). Irrigation Expansion amount to about US$ 1,300 million (White Nile Sugar Project US$ 420 million 5 700ha irrigation system and factory for cane sugar, linked with Kenana Sugar; and 30 000ha irrigation project in north Sudan). Investment in Hydropower amount to about US$ 5000 million (Marowe Dam Project US$ 1 966 million, Kajabar Dam Project in the Third Cataract US$ 1 500 million, setit and sherieg dam in upper Atbara and North Sudan). However the figures given on the table below did not add up to investment ongoing specifically in hydropower, and with the exclusion of roseries heightening which was concluded 2 years back. It can also be clearly recognized that Sudan is really facing the challenge of Sanction and inability to attract foreign finance.

Table 2-6: Sudan Investment Envelope

Time Scale	Type of Investment (Million US$)			
	Small Scale with control	Rehabilitation of Irrigation	Large Scale	Total
Short-term	6.48	1.64	4.35	12.47
Medium-term	106.95	109.25	1 089.44	1 305.64
Long-term	23.46	74.46	1 421.35	1 519.27
Total	136.89	185.35	2 515.14	2 837.38

Sourece : FAO-AQUASAT (Sirte 2008 Conference).

To formulate realistic investment trajectories for the case of Sudan, resort has been made to Sudan Nation Water Strategy, Sudan Agriculture Revival Program and Sudan Agro-Industry opportunity documents. The outcome of such desk review and based on consultation with relevant key stakeholder at the Ministries of Water and Agriculture one conclude the following:

- The short term plan for the additional water made available after Roseries heightening is to intensify winter cropping in Gezira scheme mainly wheat;
- The medium to long term plan on the Blue Nile River System after Roseries Heightening is to go for Rahad II and Kenana irrigation projects. Work on the supply canals for these schemes was initiated.
- The Upper Atbara dam on the setit river (currently under construction and anticipated to be completed by next year) is planned to irrigate around 400,000 ha in upper Atbara scheme.
- The Sudan Sudan Agro-Industry opportunity document prepared by the Federal ministry of Agriculture highlighted the feasibility and plans for sugar production expansion (120,000 ha. production capacity of about 1 million tons of sugar, namely on White Nile, Es Suki, Hourga and Nour Ed-Din, New Halfa, Rahad and Gezira schemes).

2.6.1.3 Curent situation (CS)

Based on the above the development levels for the Irrigation sectors were formulated as follow. The current situation of irrigation in the EN countries is presented in Table 2-7.

Table 2-7: Current situation (CS) for irrigation in the EN region.

Country	Current situation (CS) in the EN region (1000 ha)
Egypt	5 204
Ethiopia	140
South Sudan	0
Sudan	1 399
TOTAL	**6 743**

The potential for irrigation in the EN region based on identified national projects is estimated to be around 10,000 million ha, which highlights the challenge and constraint of water availability due to established water uses. The scope for increasing irrigated agriculture is therefore not considerable. Such a possible increase is presented in the following levels of irrigation development IS, LDI and PI.

2.6.1.4 Improved situation (IS)

The situational analysis main report has pointed out that the current area under cultivation in the current irrigation schemes is, in most of the case, less than the total command area of the schemes. An example is the ‘Gezira scheme’ in Sudan where around 377,00 ha are under cultivation today out of a scheme potential of 579,000 ha. The **assumption is made that, as a first step, the EN countries will develop irrigation so that current schemes are used according to their maximum irrigable land**. This implies rehabilitation of schemes and investment on irrigation modernization and efficient water uses as well as introducing new farm technologies for increasing productivity and reducing cost of production. This include investment in machinery, increasing uses of fertilizers, proper finance to farmers, crop diversification and liberalization including incentives for high crop returns such as perennial crops. In addition investment in improving water management on these schemes and reducing losses as well as soft investment in Agriculture research to improve seed varieties and increase productivity.

The criteria for qualifying irrigable land under improved situation is as follows:

- Any existing low performing scheme with feasibility potential for rehabilitation or irrigation modernization;
- The level of investment in rehabilitation or irrigation modernization shall not acquire supplementary storage infrastructures and the cost shall not exceed 30% of the current assets;
- All irrigations schemes that are currently under construction is categorized under improved situation as long as they are anticipated to be operation within 5-10 years.

The improved situation for development of irrigated agriculture in the EN region is therefore reflect a combination of the rehabilitation of current irrigation schemes and the schemes under construction.

Table 2-8: Improved situation (IS) for irrigation in the EN region

Country	Improved situation (IS) in the EN region (1000 ha)
Egypt	5 204
Ethiopia	172
South Sudan	13
Sudan	1 412
TOTAL	**6 827**

2.6.1.5 Large development irrigation (LDI)

It is interesting to simulate the economic impact on the EN region of major irrigation development. The previous situational analysis main report has pointed out that population in the EN region is increasing rapidly and secondly that countries have a deficit of cereals. These two issues can lead the decision makers to increase agricultural production at a higher rate than witnessed in the past. The LDI option assumes an elevated rate of irrigation development.

The criteria for qualifying irrigable land under LDI is as follows:

- Any potential irrigation scheme advanced to pre-feasibility or feasibility study level;
- All projects identified under country master plans or ENIDS diagnostic study and ranked as feasible EIRR of 10% and above.

Table 2-9: Large development irrigation (LDI) in the EN region

Country	Large irrigation development (LDI)in the EN region (1000 ha)		
	CS	IS	**LDI**
Egypt	5 204	5 230	5 260
Ethiopia	140	172	1 028
South Sudan	0	13	118
Sudan	1 399	1 412	1 939
TOTAL	**6 743**	**6 827**	**8 345**

This large development irrigation (LDI) level of development would lead to the development of around 1.701 million ha of new irrigated land in the EN region by 2045 (compare to CS).

2.6.1.6 Potential irrigation (FDP)

This option makes the assumption that all the estimated irrigation potential is converted into irrigated agriculture.

Table 2-10: Potential irrigation (FDP) in the EN region

Country	Potential irrigation (FDP) in the EN region (1000 ha)			
	CS	IS	LDI	FDP
Egypt	5 204	5 230	5 260	5 271
Ethiopia	140	172	1 028	1 392
South Sudan	0	13	118	233
Sudan	1 399	1 412	1 939	2 517
TOTAL	**6 743**	**6 827**	**8 345**	**9 403**

This potential irrigation (FDP) level of development would lead to the development of around 2.8 million ha of new irrigated land in the EN region by 2045.

2.6.2 Hydropower

Hydropower is another key water related sector in the EN region. The development levels for the hydropower sector will be directly related to the implementation of different portfolios of hydropower plants (hydropower dams/reservoirs and run-of-river hydropower plants).

Various combinations are proposed based on the inclusion of the different existing and proposed hydropower plants listed in the Scoping report.

3 development levels are proposed for the hydropower sector, as shown in the table below.

- Current situation (CS): no new development, the only hydropower plants are the existing ones;
- Improved situation (IS): Projects under construction such as GERD and Upper Atbara
- Large Development Potential: The most advanced projects up to feasibility or pre-feasibility level (Karadobi, Beko-Abo, Baro 1&2, Kajbar) are considered in addition to the improved situation ones;
- Full development hydropower (FDH): all identified projects are considered in addition to the existing ones.

Table 2-11: Hydropower Development Levels in the EN region

Country	CS		IS		FDP	
	BCM	GWhr	BCM	GWhr	BCM	GWhr
Egypt	169	11 894	169	11 457	169	11 457
Ethiopia	48	4 189	122	19 604	173	34 720
South Sudan	0	0	0	0	0	0
Sudan	25	8 421	28	10 193	31	13 994
TOTAL	**242**	**24 504**	**391**	**41 255**	**373**	**60 171**

2.6.3 Environment

In the water management and development scenarios, this sector is taken into account in terms of:

- minimum low flow levels to maintain a good ecological state in the river;
- minimum flood level to maintain the ecological services of the floods.

These minimum targets are called "environmental flows" (EF).

Two levels of development are then proposed: with or without EF.

2.6.4 Potable water supply

The development levels related to water supply will be assessed in the models only in terms of water demand. The growth of the various populations (urban and rural) has been estimated using national population growth rates. Two development levels are proposed:

- current situation (CS) – the water needs are those related to the current population within the basin,
- improved situation (IS) – considering an increase of water needs based on the population growth.
- Domestic water supply at each water abstraction node is added to livestock and irrigation water supply.

2.6.5 Livestock

The development levels related to livestock are only assessed in terms of opportunities related to growth in livestocks associated with irrigated agriculture. The Livestock and feed water requirements are added to irrigation and domestic's water supply requirements at each node.

2.6.6 Integrated watershed management

The development levels related to IWM are not assessed in the current version of the model.

2.6.7 Fisheries

The development levels related to fisheries will only concern the fishing activities in the main reservoirs. The level of development of fisheries will therefore be directly linked to the development of dams and associated reservoirs.

Three development levels are proposed for fisheries:

- Current situation (CS),
- Improved situation (IS) – supplementary fisheries related to the implementation of the most interesting and advance reservoir projects (those of the IS hydropower development level),
- Full development fisheries (FDF) – supplementary fisheries related to the implementation of all the planned reservoir projects (those of the FDH hydropower development level).

2.6.8 Non-consumptive water users

Other sectors such as tourism and navigation have been assessed in the situational analysis main report. However, the impact of their development were not assessed in the current version of the model but there is a potential for considering them as part of future amendments.

2.6.9 Synthesis of key assumptions

The key assumptions made in the study have been mentioned above or in the previous report. However, as they have a large impact on the results, it is worth remembering them again below.

They can be classified in different categories:

- The assumptions made in the economic model, concerning economic factors, like the prices of crops, the irrigation scheme construction time, the irrigation yields, the costs and benefits etc. … have a large impact on the economic results of the MSIOA. These assumptions are clearly shown in the economic model itself and it is easy to modify them when necessary.
- The assumptions made in terms of water resources quantity management have significant impact on the EN Basin Planning Model simulations, as well as on the subsequent economic calculations. The irrigation water requirements is a key assumption for the EN Basin Planning model.
- The assumptions made in terms of water resources system functioning in the EN Basin Planning Model simulations, like the behaviour of the BAS wetlands under an temperature increase scenario, with no possible calibration with historical data, have an impact on the scenarios' results.

2.7 WATER MANAGEMENT AND DEVELOPMENT SCENARIOS

2.7.1 Introduction

This section presents the various combinations of sectoral development levels (called water management and development scenarios, or just "scenarios") tested by the EN Basin Planning Model and then by the economic model. The nine scenarios are buit in a logical and step-wise manner so that the impacts of incremental changes from on scenario to another can be investigated and explained. The different levels of sectoral development levels which will be part of the nine scenarios were presented and described in the previous section of the report.

2.7.2 Scenario 1 – Baseline

The baseline scenario represents the current (2014) development level of each sector. Any other scenario should be compared to this baseline in order to compare any possible future to the current situation.

In the EN Basin Planning Model, the current water abstractions, the existing reservoirs and hydropower plants have been included.

In terms of possible prospective scenario (see section 2.2 for definition), the baseline combination might correspond to a "no change" prospective scenario.

2.7.3 Natural scenario

This "Natural" scenario is the only one proposing a lower level of water resources development than the Baseline.

The Natural scenario has been tested in order to understand the impacts of the current level of water resources development the natural state of water resources.

In the EN Basin Planning Model, the water abstractions, the man-made reservoirs and the hydropower plants have been deleted from the Baseline scenario in order to return to natural or "pre-development" conditions

One of the useful outputs from the Natural scenario is the estimation of the "naturalized" flows at different nodes of the water system. These flows have been used for the determination of the Environmental Flows requirements to be used in most of the following scenarios.

The Natural scenario does not correspond to any prospective scenario.

2.7.4 Scenario 2 – IS (improved situation)

The IS scenario is based on the Baseline scenario, but includes the IS for potable water supply, hydropower, irrigation, livestock and capture fisheries. It is similar to the IS scoping Scenario which was discussed in the "Strategic Scoping of EN Multi-Sectoral Investments" Report (Task 2).

In the EN Basin Planning Model, the water abstractions, the man-made reservoirs and the hydropower plants have been modified in order to correspond to the IS sectoral development trajectories.

In terms of possible prospective scenario, the IS scenario might correspond to a "near future" scenario in which investment is limited to irrigation modernization and rehabilitation of existing schemes deemed to be economically feasible with high economic return. The IS sectoral development trajectories of the various sectors effectively corresponds to plans being or about to be implemented. For this reason, external factors have very low impacts on the probability for the IS scenario to happen.

2.7.5 Scenario 3 – IS + stor + FDH (IS + stor + Full Development Hydropower)

This scenario is based on the "IS" scenario, but contains all the Identified hydropower plants, including those which are not planned for immediate implementation of for which feasibility studies may not yet have been carried out

In the EN Basin Planning Model, new hydropower plants and their associated storage reservoirs have been added. Corresponding minimum release requirements have been added at each new man-made reservoir.

In terms of possible prospective scenario, the "IS + stor + FDH" scenario might correspond to a "medium term future" scenario in which hydropower development is necessary in the EN region. This could correspond to a scenario in which the EN countries decided to embark on large scale power trade because demand for energy significantly increase and there is comparative advantage in terms of cost of energy generation. In reality, the provision of electricity is increasing at a much faster rate than the population or even economic growth. Current levels of acces to electricity are very low and there is a general shortage in the region so the full development of hydropower would seem a key component of any realistic prospective scenario.

2.7.6 Scenario 4 – IS + FDPI (IS + Full Development Potential Irrigation)

This scenario is based on the "IS " scenario, but the irrigation abstraction requirements have been increased.

In the EN Basin Planning Model, irrigation water requirements have been modified. Storage reservoirs associated with potential irrigation schemes have been added. This scenario is not deemed to be realistic but is aimed at investigating the deficit in water availability if countries in the EN decided to pursue their irrigation development plans unilaterally.

In terms of possible prospective scenario, the "IS + stor + EF + LDI" scenario might correspond to a "medium term future" scenario in which increased conflict among EN countries emerged due to unilateral development and absence of coordination.

2.7.7 Scenario 5 – IS + stor + Large Hydro Potential

This scenario is similar to Scenario 3 but curtails some of the less feasible hydropower projects specifically because of their lower feasibility or because of their location as part of the cascade does not permit their original full height design (for example Beko-Abo-low and Upper Mendia replacement). In another words, thi scenario seeks to optimize the sequencing of the cascade and eliminate costly plants downstream (for example the Dal Hydropower scheme in Sudan.

2.7.8 Scenario 6 – IS + Large Scale Irrigation

This scenario is similar to Scenario 4, but acknowledges the fact that water availability is a major and undeniable challenge and a limiting constraint for horizontal expansion in the irrigation sector in the EN. Hence a curtailment in the planned irrigable areas was made to include all existing irrigation schemes and potentially feasible irrigation projects under sector development Level LDI (total of 12.4 million ha).

2.7.9 Scenario 7a – IS + Large Hydro + Large Irrigation (BAS+TKZ)

This scenario aims to explore the comparative advantage between the different sub-basins in the EN. Since the Abay Blue Nile river System has huge hydropower potential, while the current level of irrigated agriculture development in Baro-Akobo-Sobat and Tekeze Atbara is minimal specifically on the upper parts of the basin, the scenario aimed to explore what could be the potential for irrigation development in the Baro-Akobo-Sobat and Tekeze-Setit-Atbara sub-basins. More specifically the scenario aimed to address principles of equitable use and sustainable use for upper riparian countries while causing no significant harm to downstream water users.

All irrigation developments that were categorized as LDI in the Baro-Akobo-Sobat and Tekeze-Setit-Atbara sub-basins were considered, water requirements for these abstraction nodes have been modified in the model and the corresponding storage infrastructure that are required to meet irrigation demand has been activated in addition to the full cascade of large scale hydropower schemes.

2.7.10 Scenario 7b – Large Hydro+IS in BAS +TZA and Large irrigation development in Sudan

Like Scenario 7a, this scenario is is aimed at "exploring the comparative advantage between the different sub-basins in the EN. This Scenario is the same as 7b, only that irrigation in BAS + TZA is reduced and irrigation in Sudan increased.

This scenario continues to explore the comparative advantage between the different sub-basins

2.7.11 Scenario 8a – IS + Large Hydro + Moderate Irrigation +

This scenario aims to address the impact of top national country priorities in irrigation expansion and its implications on water availability downstream.. The scenario explores possible moderate potential of future expansion in irrigation in the Abay-Blue Nile River System in addition to moderate to large development irrigation potential in the Baro-Akobo-Sobat and Tekeze-Setit-Atbara sub-basins. Scenario 8 therefore differs from scenario 7 through the addition of the highly feasible large scale expansion irrigation projects in the Abay Blue Nile River System .

2.7.12 Scenario 8b – IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile

Based on the principle of regional cooperation and using and managing water in the most efficient/effective way (which should be part of the MSOIA strategy), Scenarion 8b is based on Scenarion 8a but assumes that:

a) there is a change in cropping patterns with the transfer of water-greedy crops, unsuitable for arid conditions, to other areas of the basin (eg South Sudan/Ethiopia) and

b) there is an overall improvement in irrigation efficiency on all **existing** schemes throughout the basin (increased used of pressurized systems etc)

2.7.13 Scenario 8c – IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile + HAD reduced operating level

This scenario is in the same spirit of "regional cooperation and comparative advantage". This scebarion differs from Scenario 8b only in that a much lower operating level for Aswan Dam (only what's required to supply Aswann-dependant irrigation) has been assumed.

2.7.14 Scenario 9 – IS + Large Hydro+ Managed Irrigation Growth

This scenario aimed to find a hybrid approach where both opportunities for growth in Energy and Agriculture sectors could be managed within the constraints of limited water availability in the region. It is therefore built on the knowledge developed in the analsyis of the other sceanrios.

2.7.15 Synthesis

Table 2-12 overleaf summarises the proposed scenarios of water development activities as functions of the sectoral development trajectories.

Table 2-12: Summary of proposed scenarios of water development activities

Scenario		DLS		E-Flows	Hydropower				Irrigation				CC	ICM
		CS	IS		CS	IS	LDH	FDP	CS	IS	LDI	FDP		
N	Natural	no		no	no				no				no	no
1	**Scenario-1**: CS Base Case												no	no
2	**Scenario-2**: IS Improved Situation												no	no
3	**Scenario-3**: IS+Full Hydro Potential Basin Wide												no	no
4	**Scenario-4**: IS+Full Irrigation Potential Basin Wide												no	no
5	**Scenario-5**: IS+Large Hydro Potential Basin Wide												no	no
6	**Scenario-6**: IS+Large Irrigation Potential Basin Wide												no	no
7a	**Scenario-7a**: IS+Large Hydro+Large Irrigation (BAS+TZA)												no	no
7b	**Scenario-7b**: IS+LDI (Sudan)+IS (BAS+TZA)												no	no
8a	**Scenario-8a**: IS+Large Hydro+Moderate Irrigation												no	no
8b	**Scenario-8b**: IS+Large Hydro+Moderate Irrigation+cropping pattern changes on Main Nile												no	no
8c	**Scenario-8c**: IS+Large Hydro+Moderate Irrigation+cropping pattern changes on Main Nile+ HAD reduced operating level												no	no
9	**Scenario-9**: IS+Large Hydro+Managed Irrigation Growth												no	no

LEGEND

CC	Climate Change
CS	Current Situation
EF	Environmental Flows
ICM	Integrated Catchment Management
IS	Improved Situation
LDH	Large Development Hydropower
LDI	Large Development Irrigation
PH	Full Potential Hydropower
PI	Full Potential Irrigation
DLS	Domestic and Livestock Water Supply

3. Analysis of Scenarios

3.1 Introduction

The aim of this chapter is to provide the results of application of the analytical framework to the scenarios summarised in at the end of the previous chapter, in Table 2-12, and in so doing to describe the economic benefits associated with each water resources management and development scenario. At the same the impact on the water resources as key points is shown.

Each of the scenarios is briefly described and this is followed by a presentation of the water resources analysis and the economic assessment. At the end of the chapter the key conclusions are presented.

3.2 Analysis of water resources management and development scenarios

3.2.1 Scenario 1 – Baseline (current situation)

3.2.1.1 Introduction

The Baseline Scenario 1 represents the current level of development and thus includes the currently developed level of irrigation and the existing hydropower schemes in the EN region. Similarly for potable water supply, environmental flows and capture fisheries, the level of development is taken as the existing situation.

Water resources analysis

For each of the scenarios, the water resources results presentation has been standardized and presented in tables similar to Table 3-1 below This will facilitate a rapid comparison between the different scenarios.

Table 3-1: Summary of water resources results of the Baseline Scenario 1.

Water Budget	Baseline	Scenario	*Comparison*
Total Water Uses (in BCM/yr)		**89**	***N.A.***
Per major economic sector			
Irrigation+Domestic+Livestocks		*69*	*N.A.*
Hydropower & Evaporation losses		*20*	*N.A.*
Per country			
Egypt Water Uses (Inc. Evap. Lossess)		*68*	*N.A.*
Ethiopia Water Uses (Inc. Evap. Lossess)		*3*	*N.A.*
S. Sudan Water Uses (Inc. Evap. Lossess)		*0*	*N.A.*
Sudan Water Uses (Inc. Evap. Lossess)		*18*	*N.A.*
Average Annual Flows (BCM/yr)			
River Reach	Natural	Baseline	*Scenario*
Abay-Blue Nile at Kessie	16,6	16,5	16,5
Blue Nile at Deim	49,7	49,4	49,4
Blue Nile at Khartoum	53,7	44,3	44,3
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,7
White Nile at Mogren	28,7	25,5	25,5
Main Nile at Hassanab	82,4	69,2	69,2
Atbara Kilo -3	14,3	11,4	11,4
Main Nile US Aswan	96,7	77,9	77,9
Main Nile US Delta	93,0	41,1	41,1
Drainage to Medeterian Sea	0,0	9,8	9,8

In the above table, it is worth noticing that the vast majority of the current water uses is in the downstream part of the basin.

3.2.1.2 Economic analysis

The current situation does not require any new investments as it is considered as "business as usual". However, it is still possible to calculate the revenue and employment generated out of each sector as depicted in Table 3-2. The following pages summarizes the main results of the Baseline scenario in terms of costs and benefits including social indicators such as employment from each sector.

The rice and maize productions coming from the existing irrigation schemes of the area have been compared to the total rice and cereal demand of each country. This analysis has been carried out for two future situations (2020 and 2032) in the case of a "business as usual".

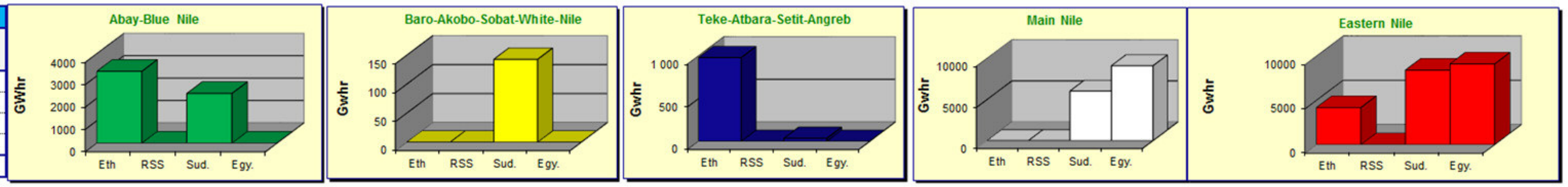
The energy production of the existing hydropower plants is around 21 721 GWh/year.

Table 3-2: Summary of the Economic Analysis results of the Baseline scenario 1.

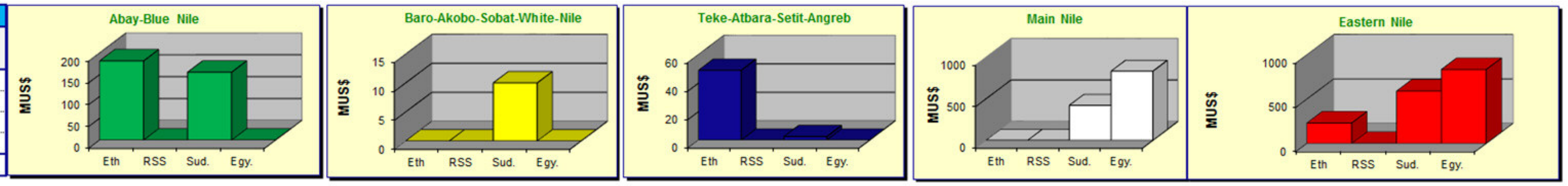
Economic & Social Indicators	Baseline	Scenario 1	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	**21 721**	***NA***
Total irrigation area (in 1000 ha)	**6 744**	**6 744**	***NA***
Water storage requirements (in BCM)	**209**	**209**	***NA***
Total Revenue Generated (in Million US$)	**4946**	**4946**	***NA***
Hydropower	*1652*	*1652*	*NA*
Irrigated Agriculture	*2254*	*2254*	*NA*
Livestock Associated with Irrigation	*990*	*990*	*NA*
Fisheries (Natural Lakes and Reservoirs)	*50*	*50*	*NA*
Total Employment Generated (in Million Jobs)	**101**	**101**	***NA***
Irrigated Agriculture	*99*	*99*	*NA*
Livestock Associated with Irrigation	*2*	*2*	*NA*
Fisheries (Natural Lakes and Reservoirs)	*0*	*0*	*NA*
Total Investment Cost (in Million US$)		4 270	*NA*
Net Present Value NPV: (in Million US$)		23 255	*NA*
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
8,30	**3,37**		

Figure 3-1: Summary of economic results for the Baseline scenario

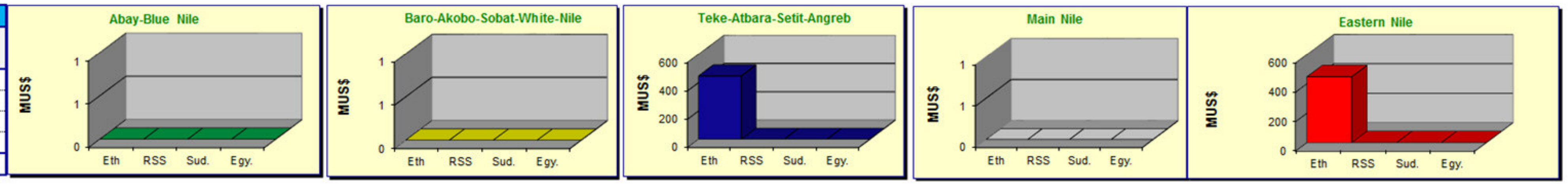
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	3 208	0	2 220	0	5 428
BAS-White Nile	0	0	143	0	143
Tekeze-Atbara	981	0	36	0	1 017
Main Nile	0	0	6 022	9 111	15 133
EN-Total	4 189	0	8 421	9 111	21 721



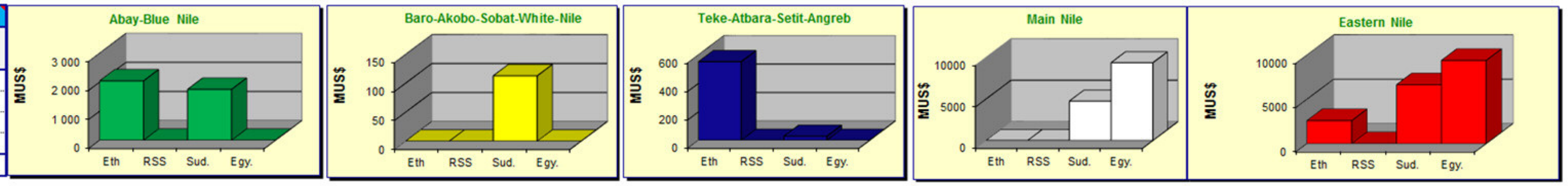
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	181	0	155	0	337
BAS-White Nile	0	0	10	0	10
Tekeze-Atbara	49	0	3	0	52
Main Nile	0	0	422	833	1 254
EN-Total	230	0	589	833	1 652



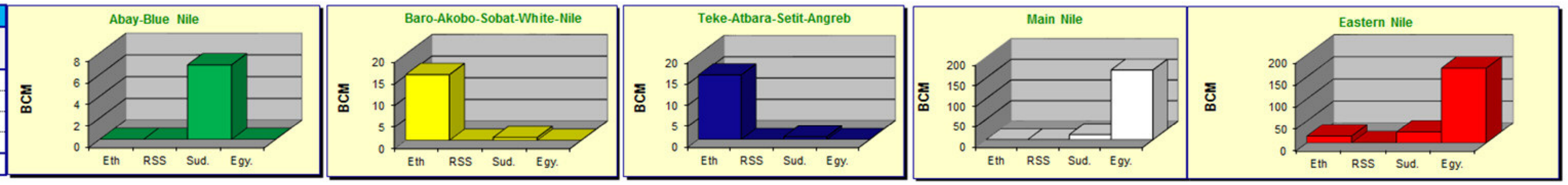
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0	0	0	0	0
BAS-White Nile	0	0	0	0	0
Tekeze-Atbara	447	0	0	0	447
Main Nile	0	0	0	0	0
EN-Total	447	0	0	0	447



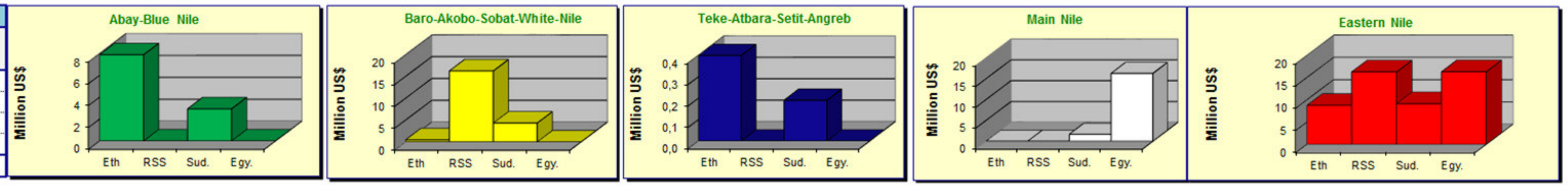
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	2 042	0	1 749	0	3 792
BAS-White Nile	0	0	113	0	113
Tekeze-Atbara	552	0	28	0	581
Main Nile	0	0	4 746	9 373	14 118
EN-Total	2 594	0	6 636	9 373	18 603



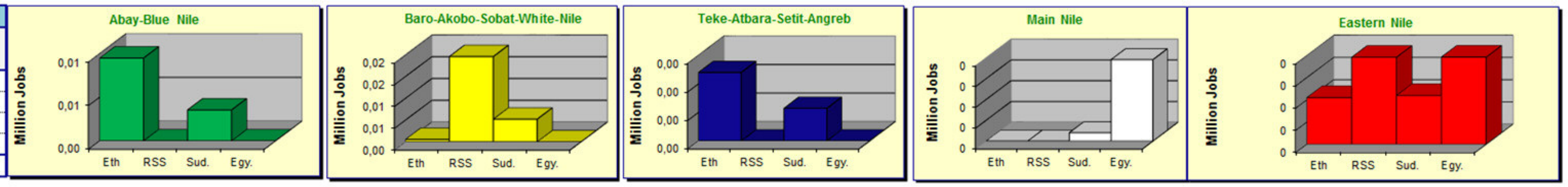
Storage Requirements: (BCM /yr))					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0	0	7	0	7
BAS-White Nile	0	0	5	0	5
Tekeze-Atbara	15	0	1	0	16
Main Nile	0	0	12	169	182
EN-Total	15	0	25	169	209



Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	8	0	3	0	11
BAS-White Nile	0	16	4	0	21
Tekeze-Atbara	0	0	0	0	1
Main Nile	0	0	2	16	18
EN-Total	9	16	9	16	50

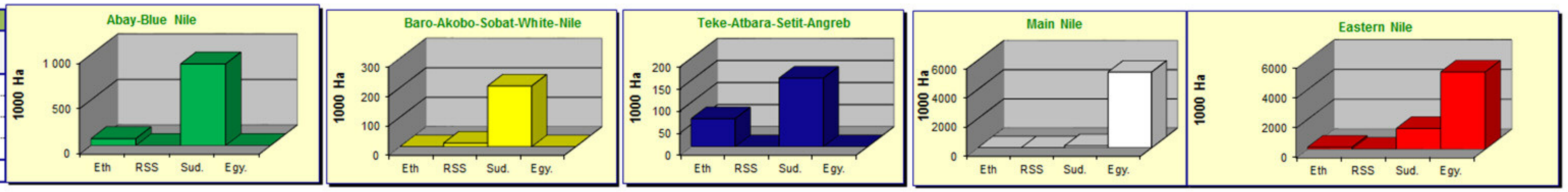


Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,01	0,00	0,00	0,00	0,01
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,01	0,02	0,01	0,02	0,06



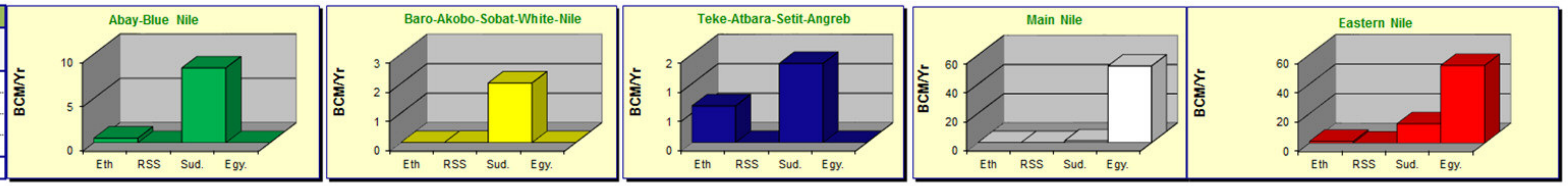
Irrigated Agriculture: Total Irrigated Areas (1000 ha)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	76	0	896	0	972
BAS-White Nile	0	13	206	0	219
Tekeze-Atbara	64	0	155	0	219
Main Nile	0	0	142	5 192	5 334
EN-Total	140	13	1 399	5 192	6 744



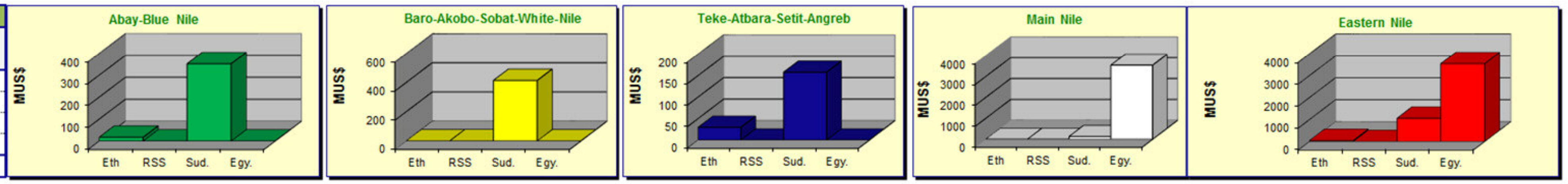
Irrigated Agriculture: Total Water Uses (BCM/Yr)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	1	0	8	0	9
BAS-White Nile	0	0	2	0	2
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	1	53	54
EN-Total	1	0	13	53	67



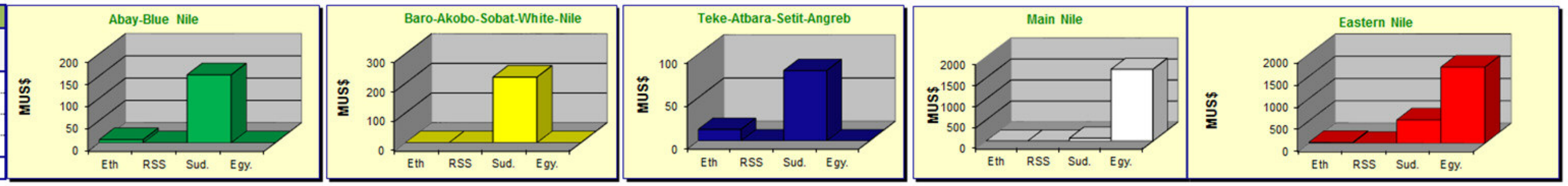
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	18	0	352	0	370
BAS-White Nile	0	0	414	0	414
Tekeze-Atbara	30	0	158	0	187
Main Nile	0	0	135	3 545	3 680
EN-Total	47	0	1 059	3 545	4 651



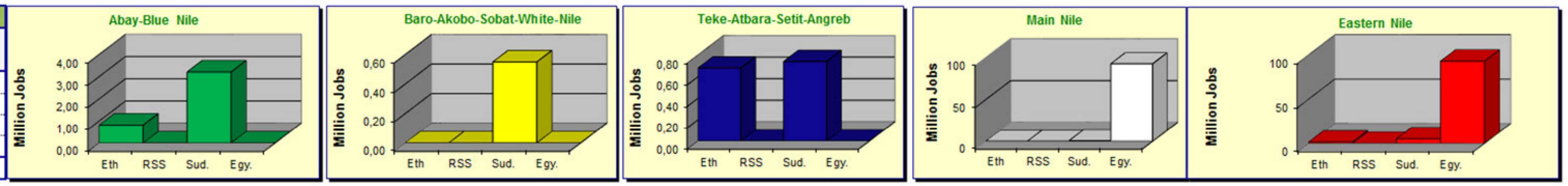
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	7	0	153	0	160
BAS-White Nile	0	0	222	0	222
Tekeze-Atbara	13	0	81	0	95
Main Nile	0	0	69	1 709	1 778
EN-Total	20	0	525	1 709	2 254



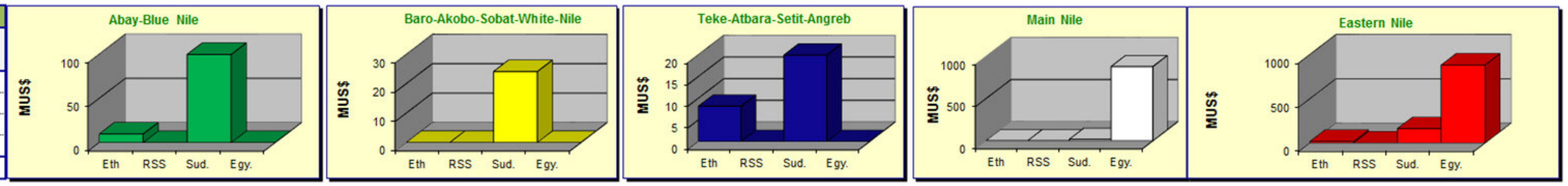
Irrigated Agriculture: Total Employment Gen. (Millions)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,81	0,00	3,21	0,00	4
BAS-White Nile	0,00	0,00	0,55	0,00	1
Tekeze-Atbara	0,68	0,00	0,74	0,00	1
Main Nile	0,00	0,00	0,67	92,72	93
EN-Total	1,49	0,00	5,17	92,72	99



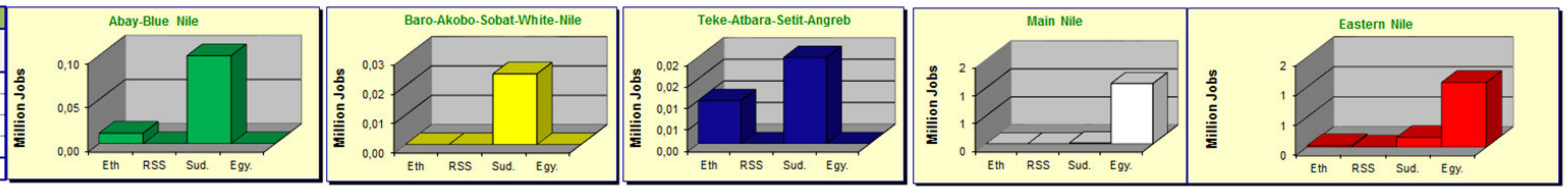
Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	10	0	100	0	109
BAS-White Nile	0	0	24	0	24
Tekeze-Atbara	8	0	20	0	28
Main Nile	0	0	18	881	899
EN-Total	18	0	162	881	1 060



Irrigated Agriculture: Livestock Employment Gen. (Millions)

Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,01	0,00	0,10	0,00	0,11
BAS-White Nile	0,00	0,00	0,02	0,00	0,02
Tekeze-Atbara	0,01	0,00	0,02	0,00	0,03
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,02	0,00	0,16	1,08	1,26



3.2.2 Scenario 2 - IS

3.2.2.1 Introduction

The IS scenario 2 represents the improved situation. With respect to hydropower, this means that the most advanced projects currently under implementation **(GERD and Upper Atbara)** are now included. With respect to irrigation, this implies that **majority of low performing existing schemes are rehabilitated so that their full command areas are operational** and their productivity is enhanced. .

3.2.2.2 Water resources analysis

The IS scenario has a limited impacts on the EN water resources. The inflow to the High Aswan Dam is expected to reduce by 4.1 BCM as a resut of some evaporation from the nex dams and some increased abstraction as irrigation schemes make use of their full command areas.

Table 3-3: Summary of water resources results of Scenario 2 (IS)

Water Budget	Baseline	Scenario 2	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**91**	***5%***
	Per major economic sector		***Share***
Irrigation+Domestic+Livestocks	*67*	*70*	*77%*
Hydropower & Evaporation losses	*20*	*21*	*23%*
	Per countryr		***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*72%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*4*	*5%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*0*	*0%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*21*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	49,2
Blue Nile at Khartoum	53,7	44,6	41,1
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,7
White Nile at Mogren	28,7	25,7	25,3
Main Nile at Hassanab	82,4	69,7	65,8
Atbara Kilo -3	14,3	11,4	11,0
Main Nile US Aswan	96,7	78,5	74,2
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	8,5

3.2.2.3 Economic analysis

In this scenario, the hydropower production rises from 21,721 GWh/year (current situation) to 41,254 GWh/year mainly as a result of GERD which is anticipated to generate about 15,415 Gwhr/Yr and to boost energy generation downstream as well through improved regulation. Upper Atbara dam is mainly for irrigation purposes with average annual energy generated of about 82 GWhr/year. The increase in irrigation water demand in Sudan is the result of the ability of these schemes to grow winter crops mainly because of the positive impact of flow regulation (GERD in addition to Roseries Heightening). The main results of the IS scenario (2) are summarised in the tables that follow in terms of cost, benefits, social and environmental externalities, employment and food security.

For this IS scenario 2:

- the ENPV of the scenario over 30 years is 147 352 million USD,,
- the increase in water uses is about 4.3 BCM as measured in HAD,
- the additional hydropower production is around 19,500 GWh/year,

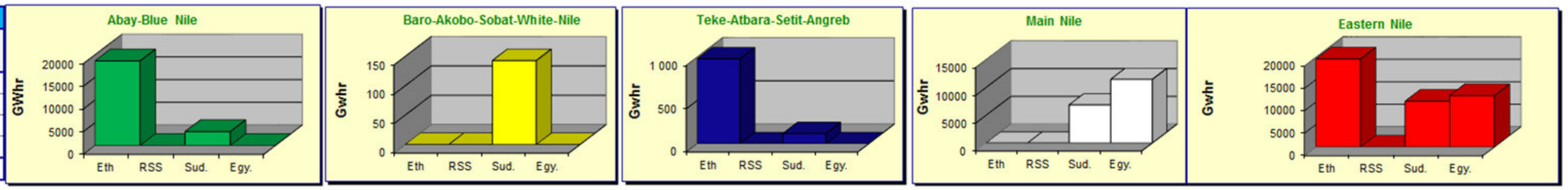
  the full time jobs generated are around 1.6 million jobs.

Table 3-3: Summary of the Economic Analysis results of Scenario 2 (IS).

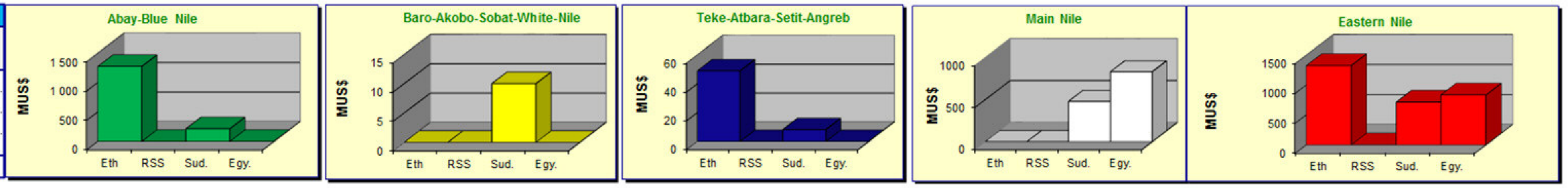
Economic & Social Indicators	Baseline	Scenario 2	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	41 254	*90%*
Total irrigation area (in 1000 ha)	**6 744**	6 804	*1%*
Water storage requirements (in BCM)	**209**	286	*37%*
Total Revenue Generated (in Million US$)	**4946**	6781	*37%*
			Sector Share
Hydrpower	*1652*	***2869***	***42%***
Irrigated Agriculture	*2254*	***2866***	***42%***
Livestock Associated with Irrigation	*990*	***990***	***15%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***55***	***1%***
Total Employment Generated (in Million Jobs)	**101**	102	*2%*
			Sector Share
Irrigated Agriculture	*99*	***101***	***98,68%***
Livestock Associated with Irrigation	*2*	***1***	***1,25%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**19 706**	
Net Present Value NPV: (in Million US$)		**38 076**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
13,40	4,11		

Figure 3-2: Summary of economic results for Scenario 2; Improved Situation (IS)

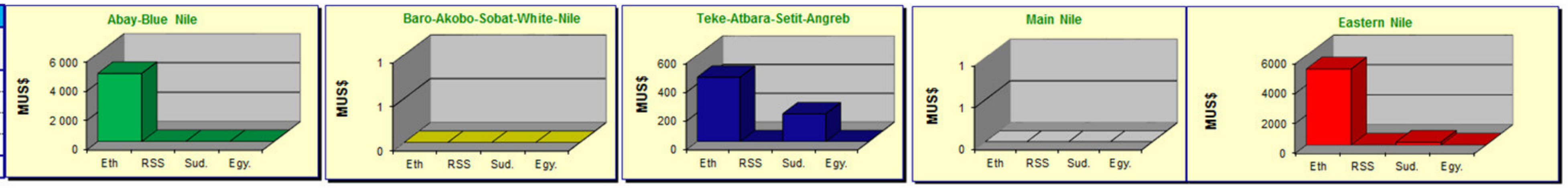
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	18 623	0	3 066	0	21 689
BAS-White Nile	0	0	143	0	143
Tekeze-Atbara	981	0	118	0	1 099
Main Nile	0	0	6 866	11 457	18 323
EN-Total	19 604	0	10 193	11 457	41 254



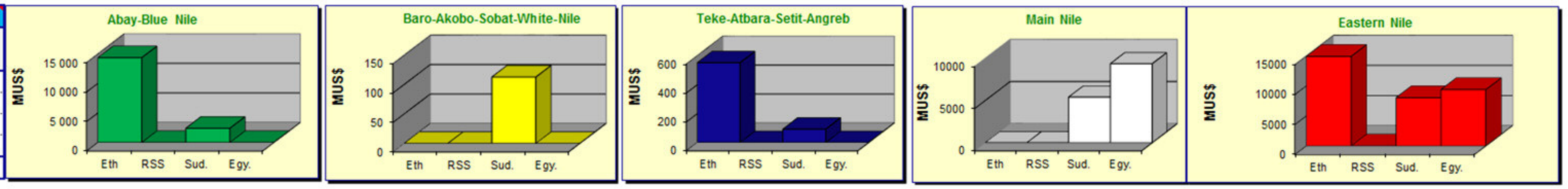
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	1 274	0	215	0	1 489
BAS-White Nile	0	0	10	0	10
Tekeze-Atbara	49	0	8	0	57
Main Nile	0	0	481	833	1 313
EN-Total	1 323	0	714	833	2 869



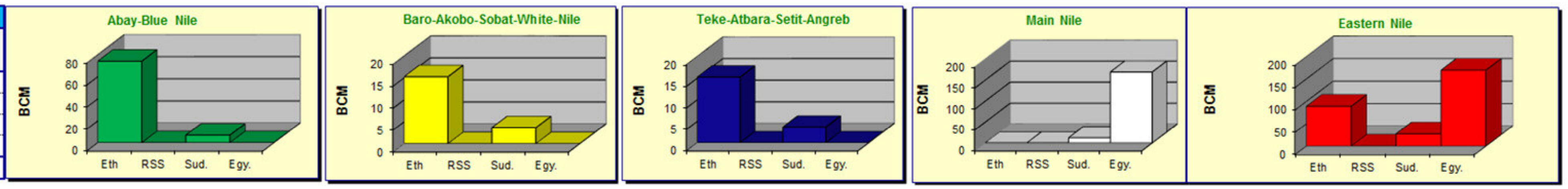
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	4 630	0	0	0	4 630
BAS-White Nile	0	0	0	0	0
Tekeze-Atbara	447	0	193	0	640
Main Nile	0	0	0	0	0
EN-Total	5 077	0	193	0	5 270



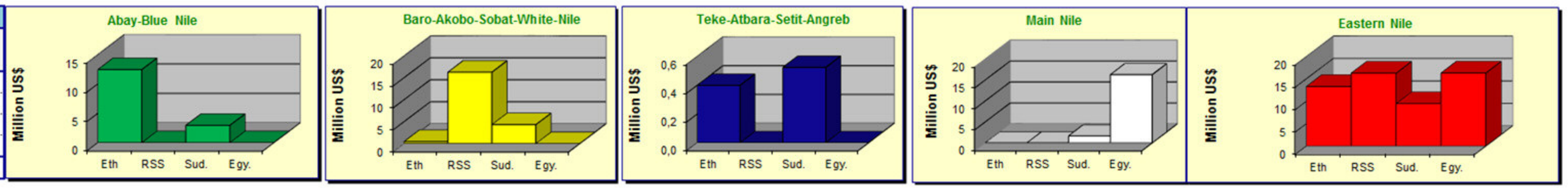
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	14 346	0	2 416	0	16 762
BAS-White Nile	0	0	113	0	113
Tekeze-Atbara	552	0	93	0	645
Main Nile	0	0	5 411	9 373	14 784
EN-Total	14 898	0	8 033	9 373	32 304



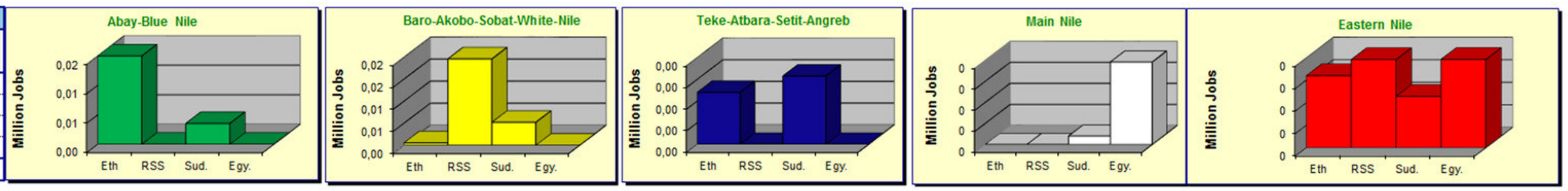
Storage Requirements: (BCM /yr))					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	74	0	7	0	81
BAS-White Nile	0	0	5	0	5
Tekeze-Atbara	15	0	4	0	19
Main Nile	0	0	12	169	182
EN-Total	89	0	28	169	286



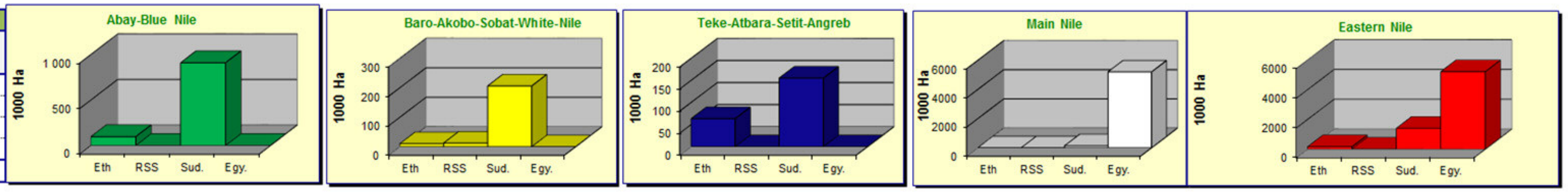
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	12	0	3	0	15
BAS-White Nile	0	16	4	0	21
Tekeze-Atbara	0	0	1	0	1
Main Nile	0	0	2	16	18
EN-Total	13	16	9	16	55



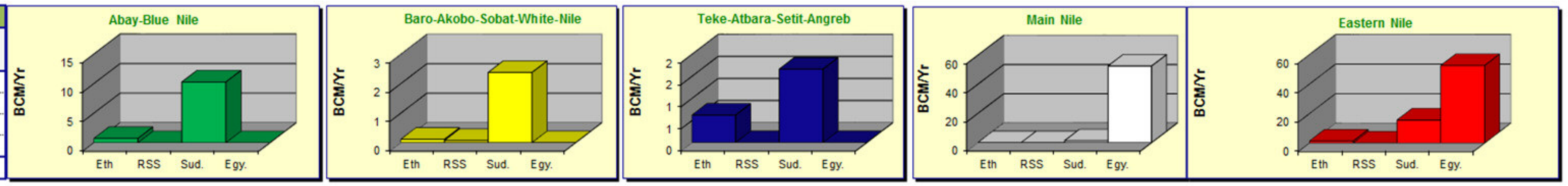
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,01	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



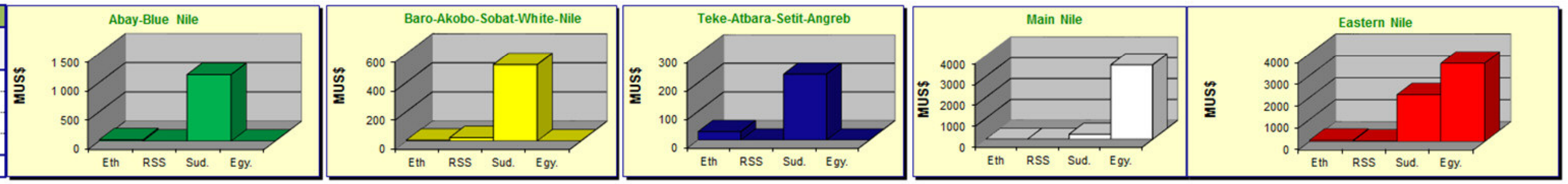
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	98	0	909	0	1 007
BAS-White Nile	10	13	206	0	229
Tekeze-Atbara	64	0	155	0	219
Main Nile	0	0	142	5 207	5 349
EN-Total	172	13	1 412	5 207	6 804



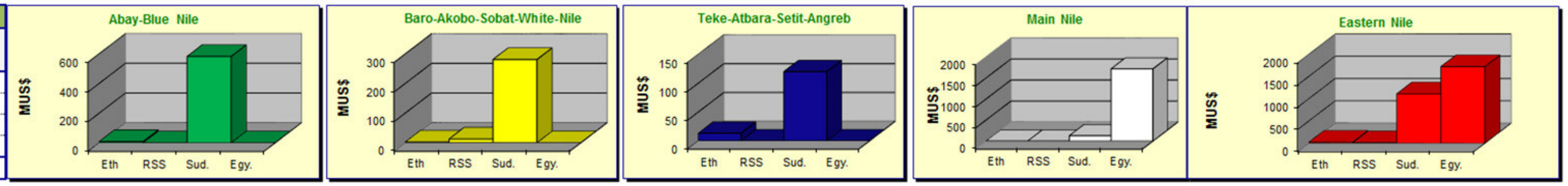
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1	0	10	0	11
BAS-White Nile	0	0	2	0	3
Tekeze-Atbara	1	0	2	0	2
Main Nile	0	0	1	53	54
EN-Total	1	0	16	53	70



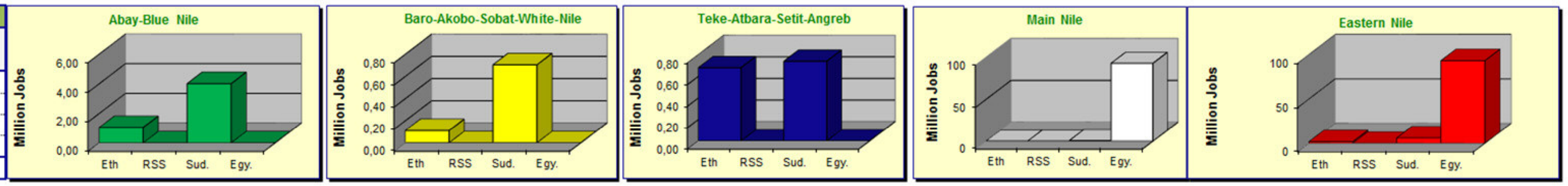
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	23	0	1 134	0	1 157
BAS-White Nile	5	23	523	0	552
Tekeze-Atbara	30	0	230	0	259
Main Nile	0	0	242	3 562	3 804
EN-Total	58	23	2 129	3 562	5 772



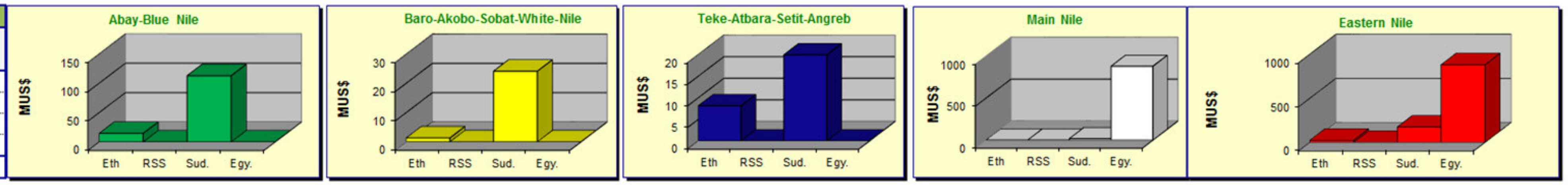
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	9	0	581	0	590
BAS-White Nile	2	13	281	0	296
Tekeze-Atbara	13	0	120	0	133
Main Nile	0	0	129	1 718	1 847
EN-Total	25	13	1 111	1 718	2 866



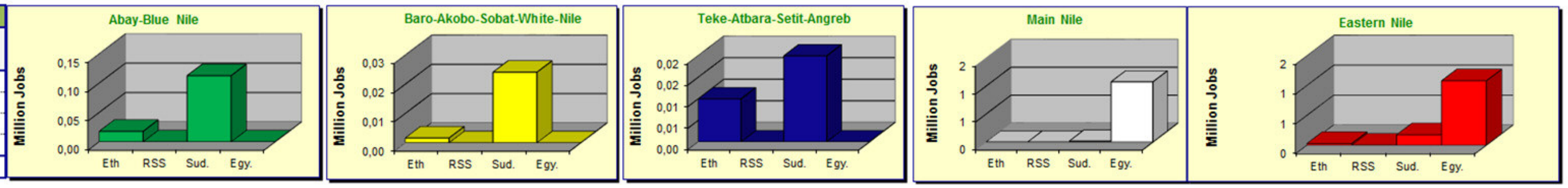
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1,05	0,00	4,01	0,00	5
BAS-White Nile	0,11	0,00	0,70	0,00	1
Tekeze-Atbara	0,68	0,00	0,74	0,00	1
Main Nile	0,00	0,00	0,67	92,99	94
EN-Total	1,84	0,00	6,13	92,99	101



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	15	0	113	0	127
BAS-White Nile	1	0	24	0	25
Tekeze-Atbara	8	0	20	0	28
Main Nile	0	0	18	881	899
EN-Total	24	0	175	881	1 080



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,11	0,00	0,13
BAS-White Nile	0,00	0,00	0,02	0,00	0,03
Tekeze-Atbara	0,01	0,00	0,02	0,00	0,03
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,03	0,00	0,17	1,08	1,28



3.2.3 Scenario 3 – IS + stor + FDH

3.2.3.1 Introduction

Scenario 3 differs only from IS scenario 2 in that **all potential hydropower projects identified in the EN under the scoping assessment** have been included. No further irrigation is included.

3.2.3.2 Water resources analysis

As can be seen in the table below, the inflow to the High Aswan Dam is further reduced from 78.5 BCM (CS) to 74.2 (IS) to 71.4 BCM in this scenario as a results of evaporation losses in the new reservoirs. However, there is no impact on flows into the downstream delta or the Meditteranean Sea. This is because (especially with the regulated Abbay/Blue Nile) there is excess storage in the Aswan Dam to continue with releases as before.

Table 3-4 : Summary of water resources results for Scenario 3 (SS+stor+FDH)

Water Budget	Baseline	Scenario 3	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**94**	***8%***
		Per major economic sector	***Share***
Irrigation+Domestic+Livestocks	*67*	*70*	*75%*
Hydropower & Evaporation losses	*20*	*24*	*25%*
		Per country	***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*70%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*6*	*7%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*0*	*0%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*22*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	48,1
Blue Nile at Khartoum	53,7	44,6	39,3
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,7
White Nile at Mogren	28,7	25,7	25,3
Main Nile at Hassanab	82,4	69,7	65,8
Atbara Kilo -3	14,3	11,4	11,0
Main Nile US Aswan	96,7	78,5	74,2
Main Nile US Delta	93,0	43,1	43,1
Drainage to Mediterranean Sea	0,0	12,6	8,5

3.2.3.3 Economic analysis

The main results of the Scenario 3 are summarised in the table below in terms of cost, benefits, social and environmental externalities, employment and food security.

For this scenario 3:

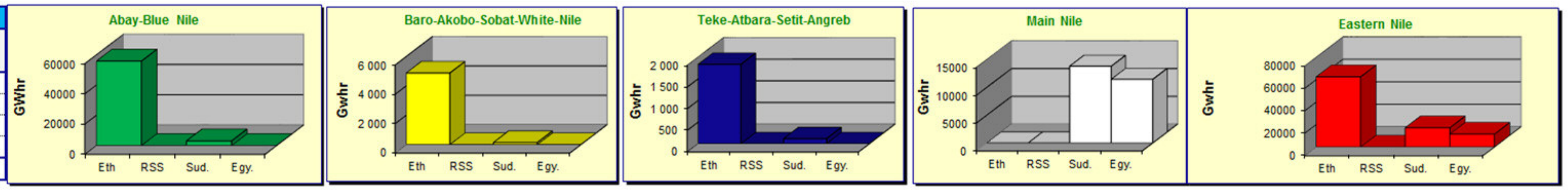
- There is significant boost in energy generation from about 21,721 Gwhr/year (CS) to 91,098 Gwhr/yr (Scenario 3).
- The increase in total annual revenue generated is about 109% (from 4.9 Billion US$/yr in current situation to about 10.1 Billion US$/yr)
- the ENPV over the 30 years horizon of the evaluation is 184 679 M USD
- the additional storage requirements is about 220 BCM.
- the full time jobs generated are around 1.6 million jobs.

Table 3-5: Summary of the Economic Analysis results for scenario 3

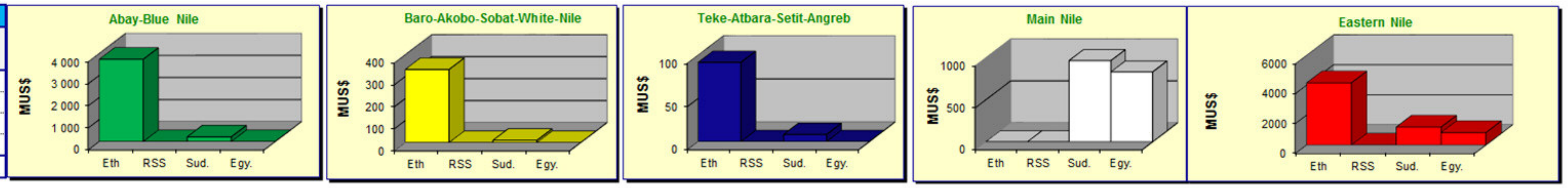
Economic & Social Indicators	Baseline	Scenario 3	*Comparison*
Total HP generated **(annual average production, in GWh)**	**21 721**	**91 098**	*319%*
Total irrigation area (in 1000 ha)	**6 744**	6 804	*1%*
Water storage requirements (in BCM)	**209**	430	*106%*
Total Revenue Generated (in Million US$)	**4946**	10103	*104%*
			Sector Share
Hydropower	*1652*	***6185***	***61%***
Irrigated Agriculture	*2254*	***2866***	***28%***
Livestock Associated with Irrigation	*990*	***990***	***10%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***62***	***1%***
Total Employment Generated (in Million Jobs)	100,7	102,3	*1,6%*
			Sector Share
Irrigated Agriculture	*99*	***101***	***98,67%***
Livestock Associated with Irrigation	*2*	***1***	***1,25%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**31 821**	
Net Present Value NPV: (in Million US$)		**75 403**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
25,91	4,11		

Figure 3-3: Summary of economic results for Scenario 3: IS + storage + full development of hydropower (IS + stor + FDH)

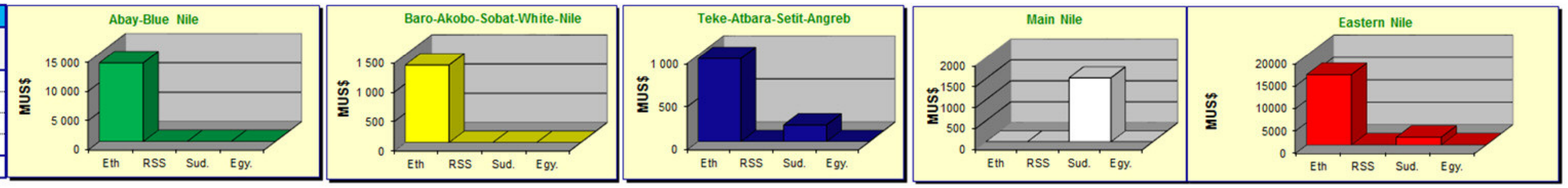
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	55 789	0	3 066	0	58 855
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	13 817	11 457	25 274
EN-Total	62 497	0	17 144	11 457	91 098



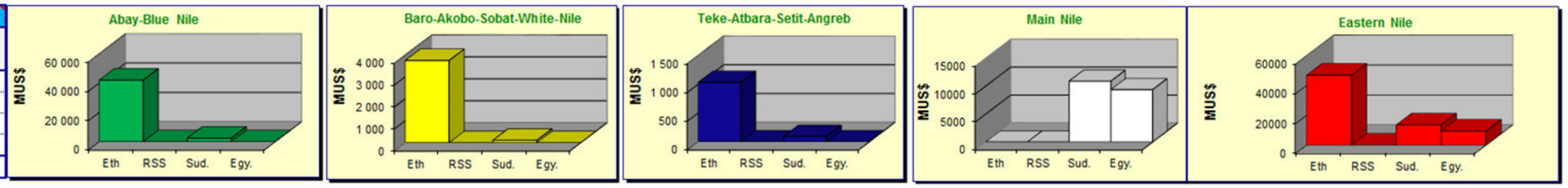
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	3 729	0	215	0	3 943
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	967	833	1 800
EN-Total	4 152	0	1 200	833	6 185



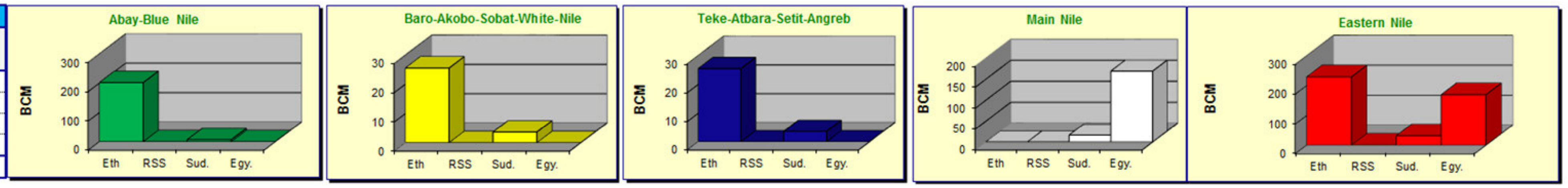
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	13 383	0	0	0	13 383
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	1 523	0	1 523
EN-Total	15 669	0	1 716	0	17 385



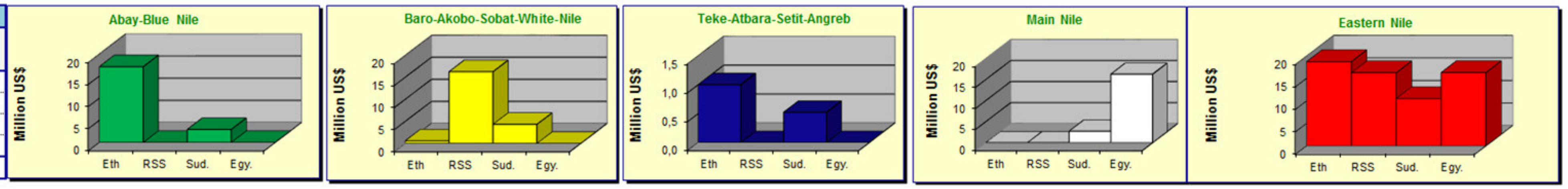
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	41 977	0	2 416	0	44 393
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	10 888	9 373	20 261
EN-Total	46 748	0	13 510	9 373	69 631



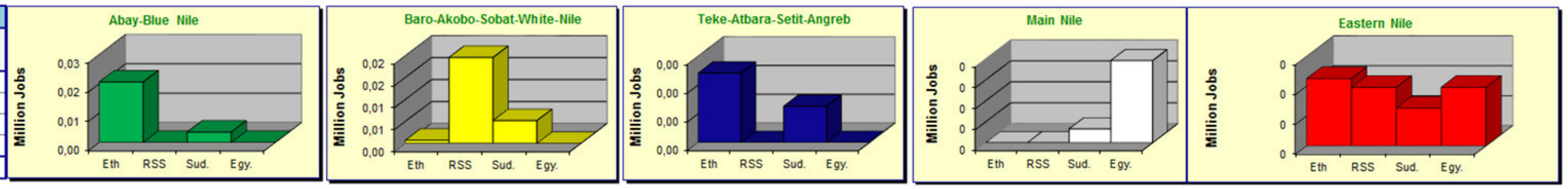
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	202	0	7	0	209
BAS-White Nile	1	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	16	169	186
EN-Total	229	0	32	169	430



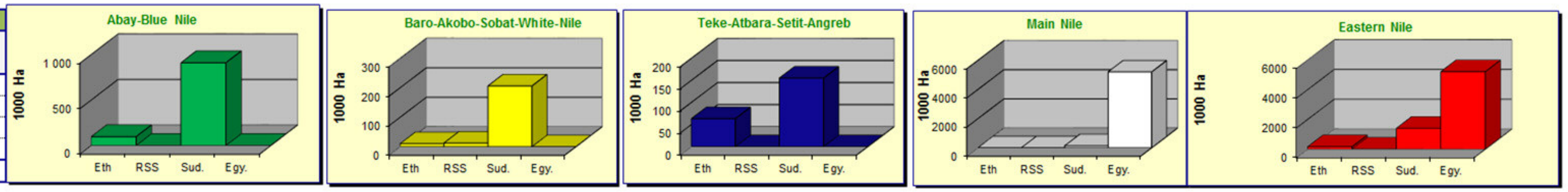
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	17	0	3	0	20
BAS-White Nile	1	16	4	0	21
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	3	16	19
EN-Total	19	16	11	16	62



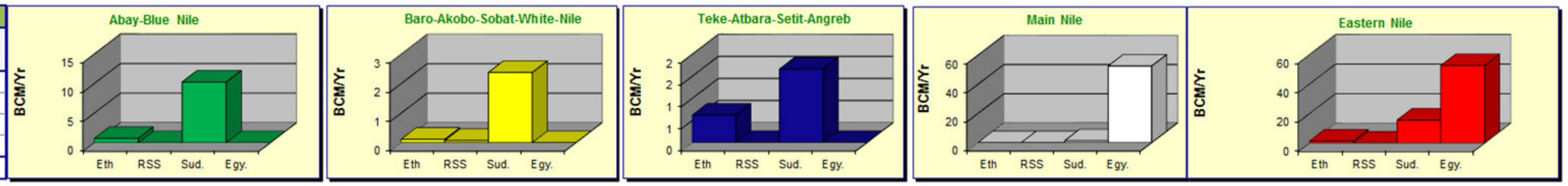
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



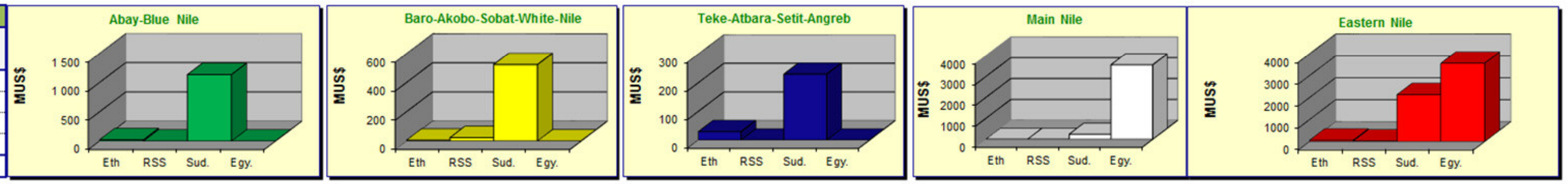
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	98	0	909	0	1 007
BAS-White Nile	10	13	206	0	229
Tekeze-Atbara	64	0	155	0	219
Main Nile	0	0	142	5 207	5 349
EN-Total	172	13	1 412	5 207	6 804



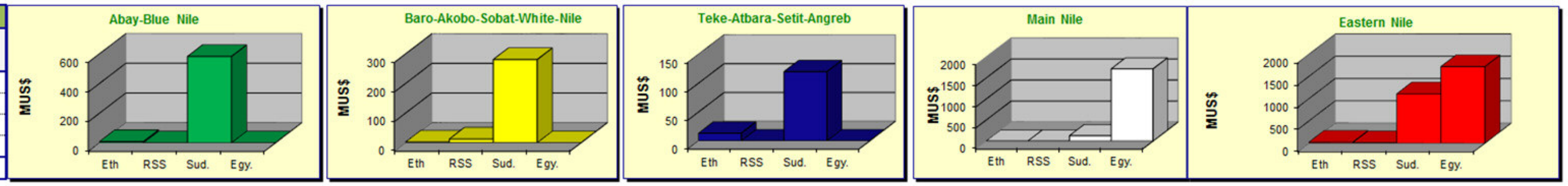
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1	0	10	0	11
BAS-White Nile	0	0	2	0	3
Tekeze-Atbara	1	0	2	0	2
Main Nile	0	0	1	53	54
EN-Total	1	0	16	53	70



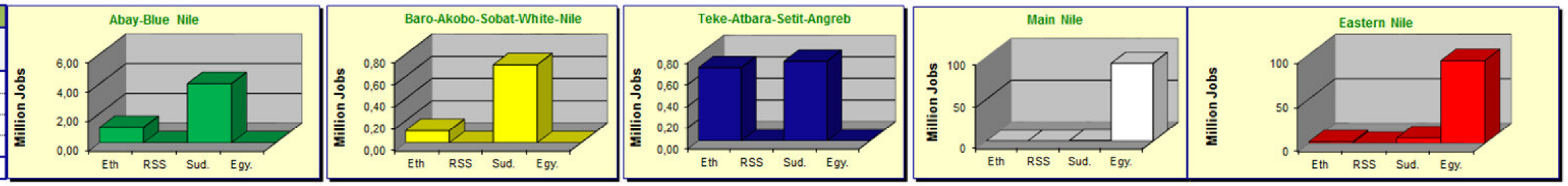
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	23	0	1 134	0	1 157
BAS-White Nile	5	23	523	0	552
Tekeze-Atbara	30	0	230	0	259
Main Nile	0	0	242	3 562	3 804
EN-Total	58	23	2 129	3 562	5 772



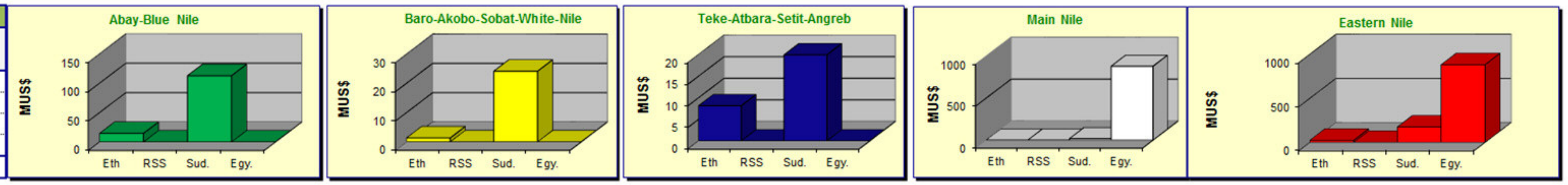
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	9	0	581	0	590
BAS-White Nile	2	13	281	0	296
Tekeze-Atbara	13	0	120	0	133
Main Nile	0	0	129	1 718	1 847
EN-Total	25	13	1 111	1 718	2 866



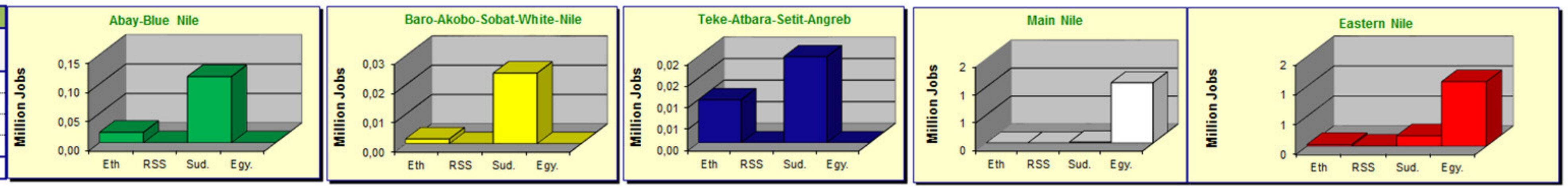
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1,05	0,00	4,01	0,00	5
BAS-White Nile	0,11	0,00	0,70	0,00	1
Tekeze-Atbara	0,68	0,00	0,74	0,00	1
Main Nile	0,00	0,00	0,67	92,99	94
EN-Total	1,84	0,00	6,13	92,99	101



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	15	0	113	0	127
BAS-White Nile	1	0	24	0	25
Tekeze-Atbara	8	0	20	0	28
Main Nile	0	0	18	881	899
EN-Total	24	0	175	881	1 080



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,11	0,00	0,13
BAS-White Nile	0,00	0,00	0,02	0,00	0,03
Tekeze-Atbara	0,01	0,00	0,02	0,00	0,03
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,03	0,00	0,17	1,08	1,28



3.2.4 Scenario 4: IS + Full Irrigation Potential Basin Wide

3.2.4.1 Introduction

Scenario 4 differs from IS scenario 2 in that all potential irrigation projects in the 4 EN sub-basins has been included. Hydropower is set back to IS levels (GERD and Upper Atbaba only)

3.2.4.2 Water resources analysis

Table 3-6 below **shows a water deficit of about 19.3 BCM/Yr**. This scenario reflects the fact that in the event that countries in the EN pursue their irrigation expansion plans unilaterally there would be a serious deficit which might results in conflicts between different users in the basin.

Table 3-6: Summary of water resources results for Scenario 4 : IS + Full Irrigation Potential

Water Budget	Baseline	Scenario 4	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**126**	***45%***
Per major economic sector			***Share***
Irrigation+Domestic+Livestocks	*67*	*104*	*83%*
Hydropower & Evaporation losses	*20*	*22*	*17%*
Per country			***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*68*	*54%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*17*	*13%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*3*	*3%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*38*	*30%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	15,6
Blue Nile at Deim	49,7	49,4	46,2
Blue Nile at Khartoum	53,0	44,6	23,7
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	21,9
White Nile at Mogren	28,7	25,7	16,8
Main Nile at Hassanab	82,4	69,7	39,8
Atbara Kilo -3	14,3	11,4	6,6
Main Nile US Aswan	96,7	78,5	45,6
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	-19,3

3.2.4.3 Economic analysis

Table 3-7 summarizes the main results of scenario 4 in terms of cost, benefits, social and environmental externalities, employment and food security. Since this scenario is not viable because of constraint in water availability, detailed presentation of the economic results are not presented.

Table 3-7: Summary of the economic results for Scenario 4 : IS + Full Irrigation Potential

Economic & Social Indicators	Baseline	Scenario 4	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	41 254	*90%*
Total irrigation area (in 1000 ha)	**6 744**	9 423	*40%*
Water storage requirements (in BCM)	**209**	286	*37%*
Total Revenue Generated (in Million US$)	**4946**	9440	*91%*
			Sector Share
Hydrpower	*1652*	***2870***	***30%***
Irrigated Agriculture	*2254*	***5524***	***59%***
Livestock Associated with Irrigation	*990*	***990***	***10%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***56***	***1%***
Total Employment Generated (in Million Jobs)	100,7	120,3	*19,5%*
			Sector Share
Irrigated Agriculture	*99*	***118***	***98,48%***
Livestock Associated with Irrigation	*2*	***2***	***1,47%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,06%***
Total Investment Cost (in Million US$)		**53 264**	
Net Present Value NPV: (in Million US$)		32 958	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
13,34	5,29		

Figure 3-4: Summary of economic results for Scenario 4: Improved situation + full irrigation potential basinwide

Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	18 623	0	3 066	0	21 689
BAS-White Nile	0	0	143	0	143
Tekeze-Atbara	981	0	118	0	1 099
Main Nile	0	0	6 866	11 457	18 323
EN-Total	19 604	0	10 193	11 457	41 254

Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	1 275	0	215	0	1 490
BAS-White Nile	0	0	10	0	10
Tekeze-Atbara	49	0	8	0	57
Main Nile	0	0	481	833	1 313
EN-Total	1 324	0	714	833	2 870

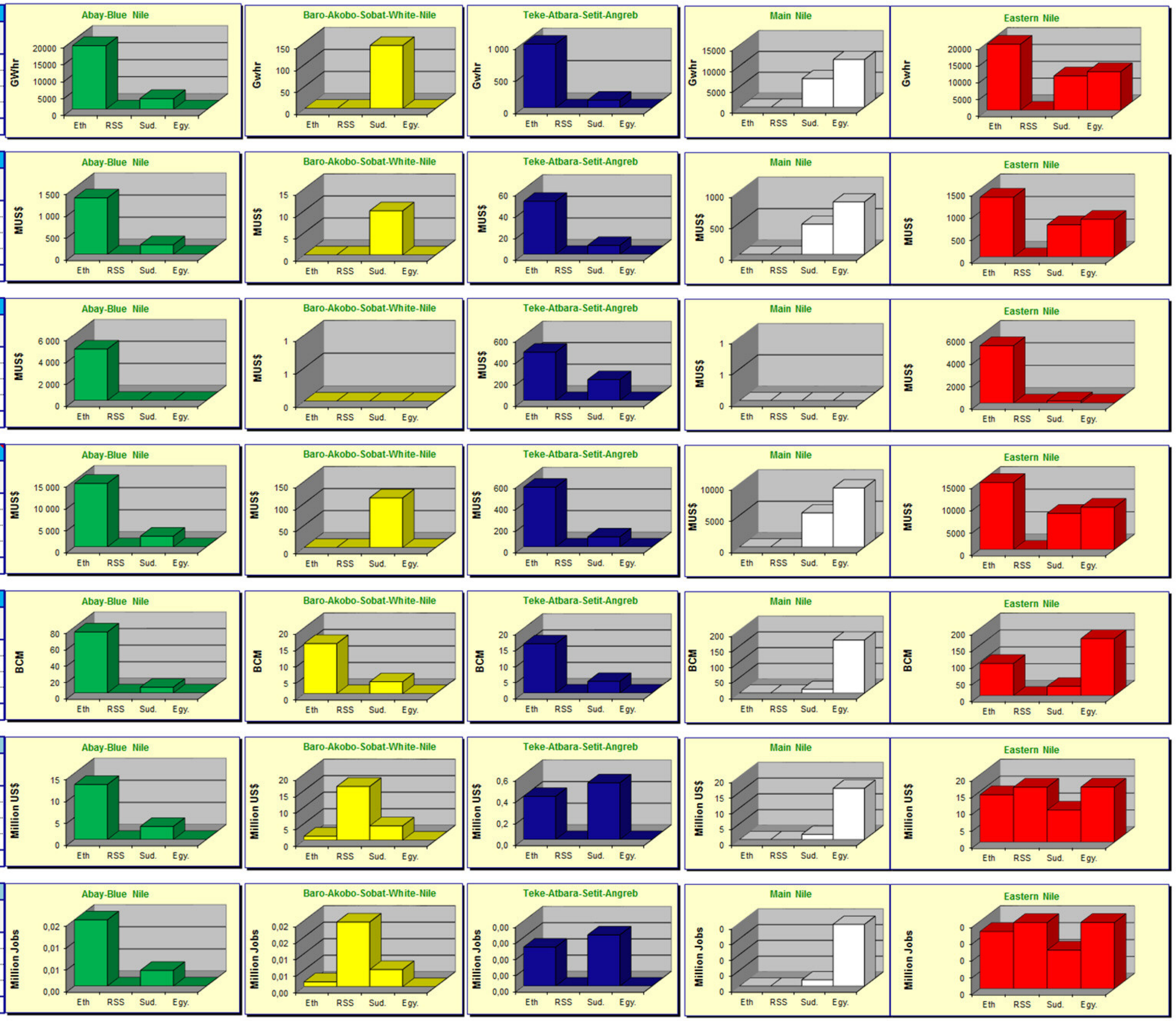
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	4 652	0	0	0	4 652
BAS-White Nile	0	0	0	0	0
Tekeze-Atbara	447	0	193	0	640
Main Nile	0	0	0	0	0
EN-Total	5 099	0	193	0	5 292

Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	14 354	0	2 416	0	16 770
BAS-White Nile	0	0	113	0	113
Tekeze-Atbara	552	0	93	0	645
Main Nile	0	0	5 411	9 373	14 784
EN-Total	14 906	0	8 033	9 373	32 312

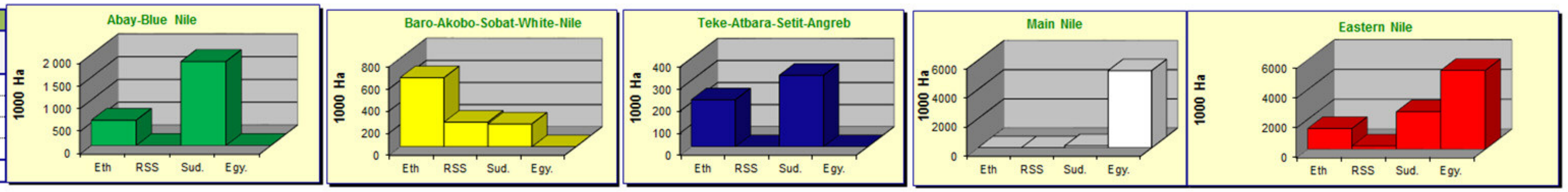
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	74	0	7	0	81
BAS-White Nile	7	0	5	0	5
Tekeze-Atbara	15	0	4	0	19
Main Nile	0	0	12	169	182
EN-Total	96	0	28	169	286

Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	12	0	3	0	15
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	0	0	1	0	1
Main Nile	0	0	2	16	18
EN-Total	14	16	9	16	56

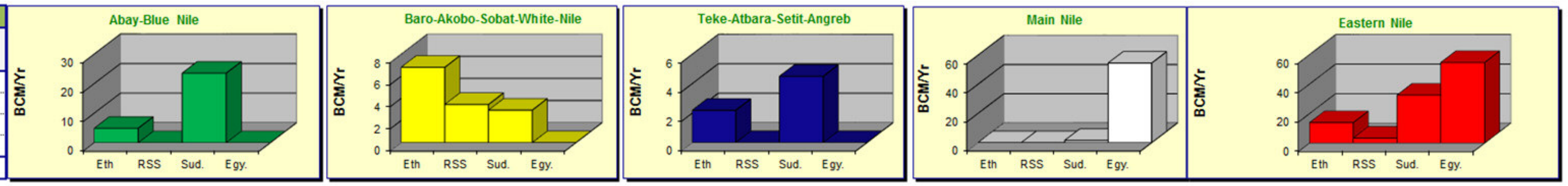
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	0,01	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



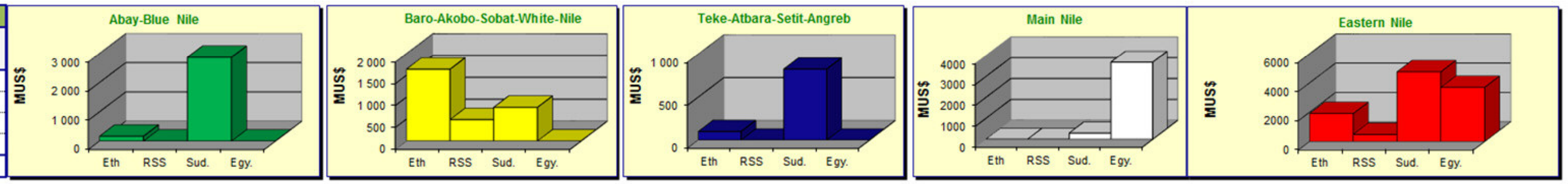
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	555	0	1 846	0	2 401
BAS-White Nile	624	223	206	0	1 053
Tekeze-Atbara	213	0	323	0	536
Main Nile	0	0	142	5 291	5 433
EN-Total	1 392	223	2 517	5 291	9 423



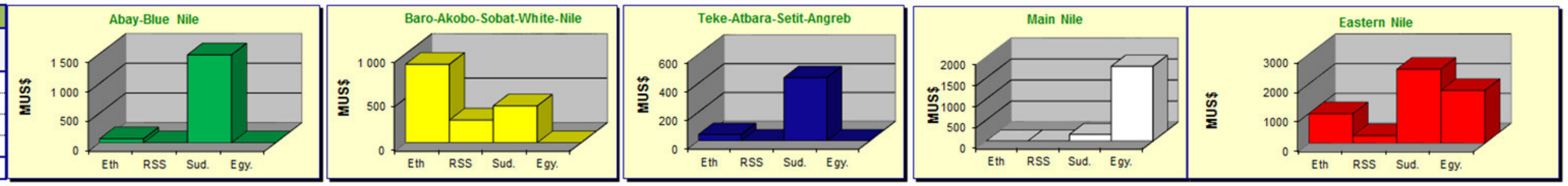
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	5	0	24	0	28
BAS-White Nile	7	3	3	0	13
Tekeze-Atbara	2	0	5	0	7
Main Nile	0	0	2	55	56
EN-Total	14	3	33	55	104



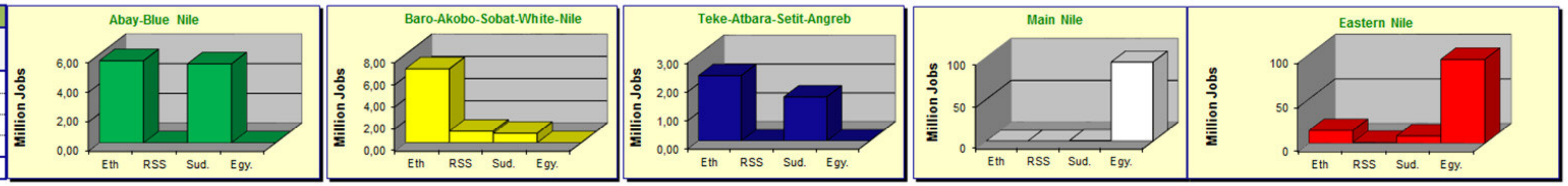
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	168	0	2 864	0	3 032
BAS-White Nile	1 639	489	767	0	2 895
Tekeze-Atbara	100	0	826	0	926
Main Nile	0	0	297	3 691	3 988
EN-Total	1 907	489	4 754	3 691	10 840



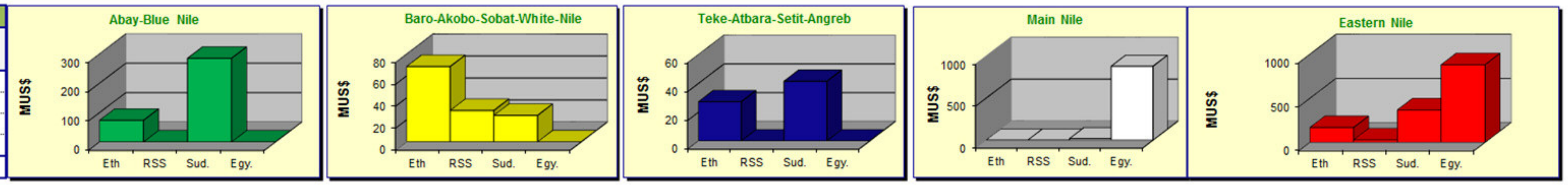
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	68	0	1 481	0	1 549
BAS-White Nile	883	256	414	0	1 553
Tekeze-Atbara	45	0	439	0	484
Main Nile	0	0	159	1 779	1 938
EN-Total	996	256	2 493	1 779	5 524



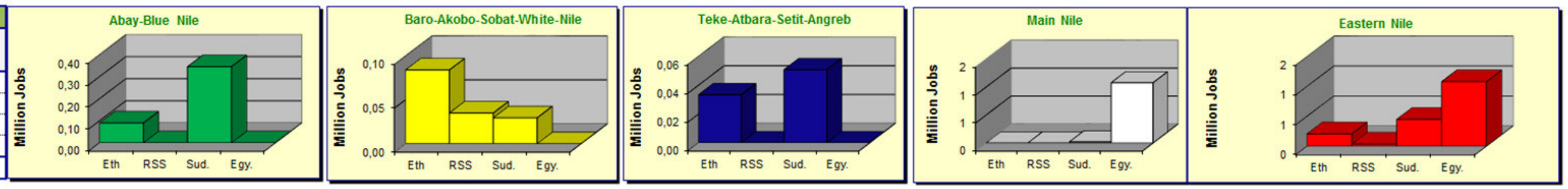
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	5,55	0,00	5,34	0,00	11
BAS-White Nile	6,69	1,06	0,87	0,00	9
Tekeze-Atbara	2,28	0,00	1,54	0,00	4
Main Nile	0,00	0,00	0,67	94,49	95
EN-Total	14,52	1,06	8,42	94,49	118



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	74	0	285	0	358
BAS-White Nile	69	29	24	0	121
Tekeze-Atbara	27	0	42	0	69
Main Nile	0	0	18	881	899
EN-Total	170	29	368	881	1 447



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,09	0,00	0,34	0,00	0,43
BAS-White Nile	0,08	0,03	0,03	0,00	0,15
Tekeze-Atbara	0,03	0,00	0,05	0,00	0,08
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,21	0,03	0,45	1,08	1,77



3.2.5 Scenario 5 – IS + Large Hydro Potential Basin Wide

3.2.5.1 Introduction

This scenario builds on scenario 3, which considered the full development of hydropowere potential with only the IS level of irrigation. However, in this scenario issues related to proper sequencing of the cascade of reservoirs upstream are addressed and hydropower schemes with low feasibility on the main Nile in Sudan have been excluded. This takes into consideration that **opportunities of power trade will minimize the need for costly reservoirs with high evaporation losses along the main Nile river stem**.

3.2.5.2 Water resources analysis

Table 3-8 shows that planned hydropower developments in the EN region has minimal impact on the regional water resources compared to other scenarios. The total flow at HAD is reduced by about 6.1 BCM (from 78.5 BCM base case to 72.4 BCM).

Table 3-8: Summary of water resources results for Scenario 5 : IS + Large Hydro Potential

Water Budget	Baseline	Scenario 5	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**93**	***7%***
		Per major economic sector	***Share***
Irrigation+Domestic+Livestocks	*67*	*70*	*75%*
Hydropower & Evaporation losses	*20*	*23*	*25%*
		Per country	***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*71%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*5*	*6%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*0*	*0%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*21*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	49,2
Blue Nile at Khartoum	53,7	44,6	41,1
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,7
White Nile at Mogren	28,7	25,7	25,3
Main Nile at Hassanab	82,4	69,7	65,8
Atbara Kilo -3	14,3	11,4	11,0
Main Nile US Aswan	96,7	78,5	72,4
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	9,5

3.2.5.3 Economic analysis

In this scenario, 10 new hydropower plants are implemented. The hydropower production raises from 41,254 GWh/year in the improved situation to 60 171 Gwhr/year.

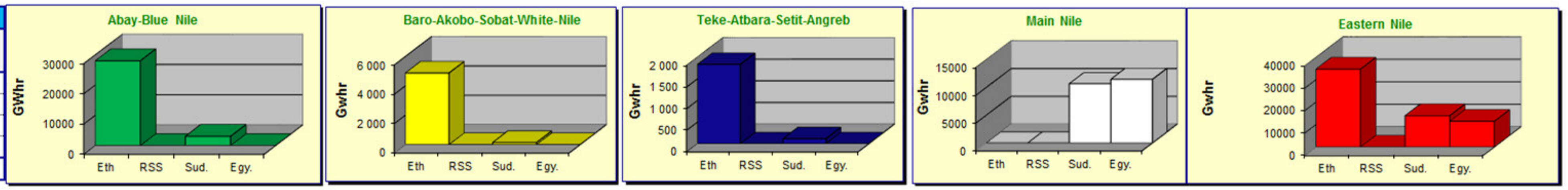
The following pages summarizes the main results of the IS +Large Hydro scenario 5 in terms of cost, benefits, social and environmental externalities, employment and food security. Because of the omission of the leass feasible hydropower schemes the net revenue generated per m^3 by hydropower rises by $5c/m^3$ tp $18.17c/m^3$.

Table 3-9: Summary of the economic results for Scenario 5 : IS + Large Hydro-Potential

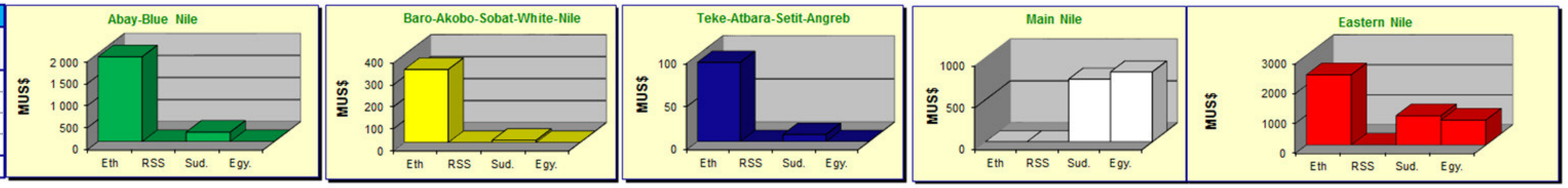
Economic & Social Indicators	**Baseline**	**Scenario 5**	***Comparison***
Total HP generated (annual average production, in GWh)	**21 721**	60 171	*177%*
Total irrigation area (in 1000 ha)	**6 744**	6 804	*1%*
Water storage requirements (in BCM)	**209**	341	*63%*
Total Revenue Generated (in Million US$)	**4946**	8073	*63%*
			Sector Share
Hydrpower	*1652*	***4158***	***52%***
Irrigated Agriculture	*2254*	***2866***	***36%***
Livestock Associated with Irrigation	*990*	***990***	***12%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***58***	***1%***
Total Employment Generated (in Million Jobs)	**101**	102	*2%*
			Sector Share
Irrigated Agriculture	*99*	***101***	***98,68%***
Livestock Associated with Irrigation	*2*	***1***	***1,25%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**23 369**	
Net Present Value NPV: (in Million US$)		51 875	*139%*
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
18,17	4,11		

Figure 3-5: Summary of economic results for Scenario 5: Improved situation (IS) + large hydropower potential basinwide

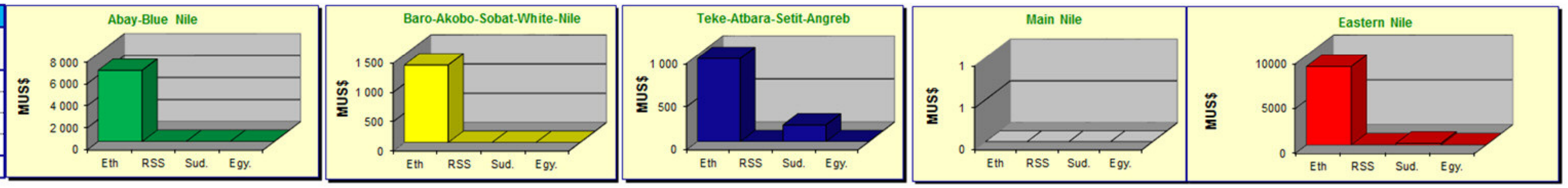
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	28 012	0	3 066	0	31 078
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	10 667	11 457	22 124
EN-Total	34 720	0	13 994	11 457	60 171



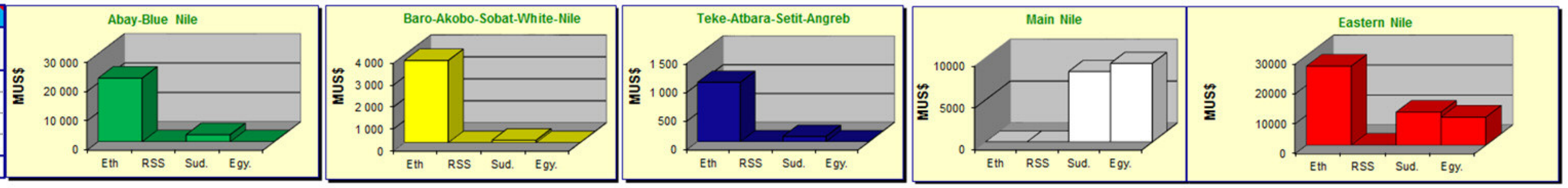
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1 922	0	215	0	2 137
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	747	833	1 579
EN-Total	2 346	0	980	833	4 158



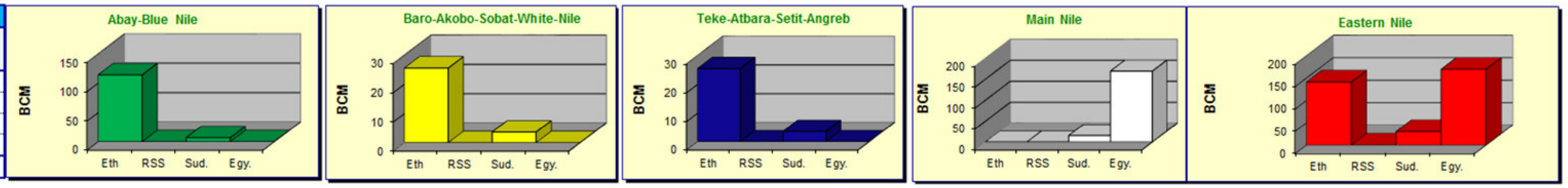
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	6 454	0	0	0	6 454
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	8 740	0	193	0	8 933



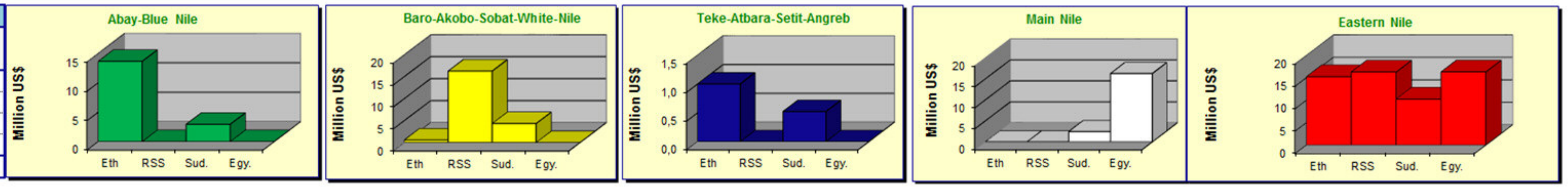
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	21 643	0	2 416	0	24 059
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	8 406	9 373	17 779
EN-Total	26 414	0	11 028	9 373	46 814



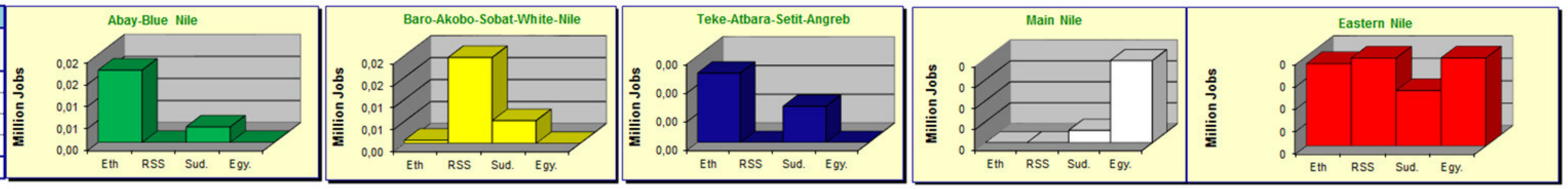
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	114	0	7	0	121
BAS-White Nile	1	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	15	169	185
EN-Total	141	0	31	169	341



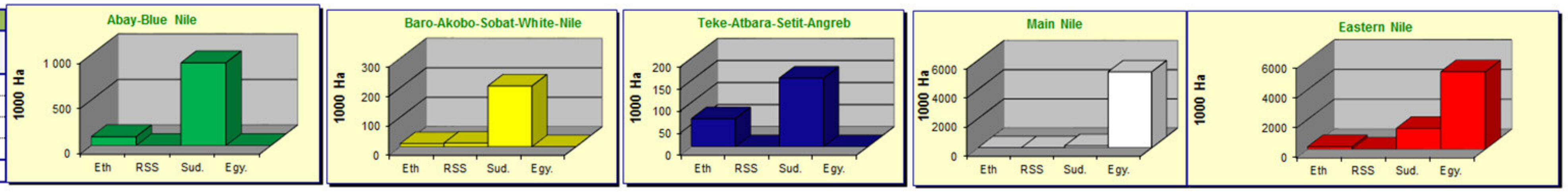
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	14	0	3	0	17
BAS-White Nile	1	16	4	0	21
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	19
EN-Total	15	16	10	16	58



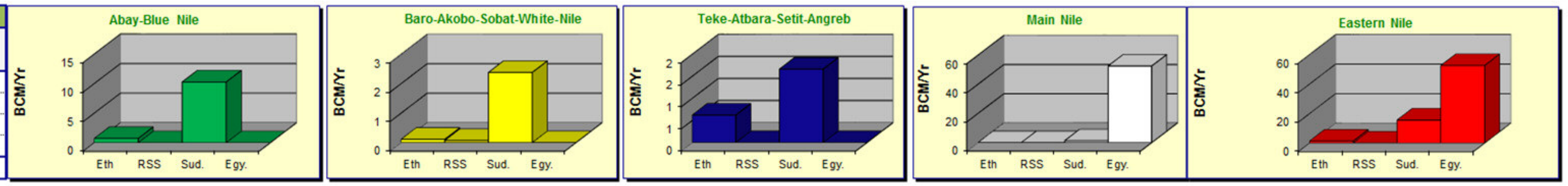
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



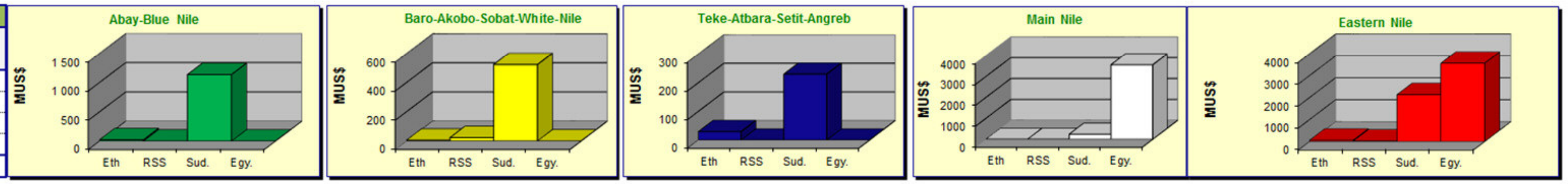
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	98	0	909	0	1 007
BAS-White Nile	10	13	206	0	229
Tekeze-Atbara	64	0	155	0	219
Main Nile	0	0	142	5 207	5 349
EN-Total	172	13	1 412	5 207	6 804



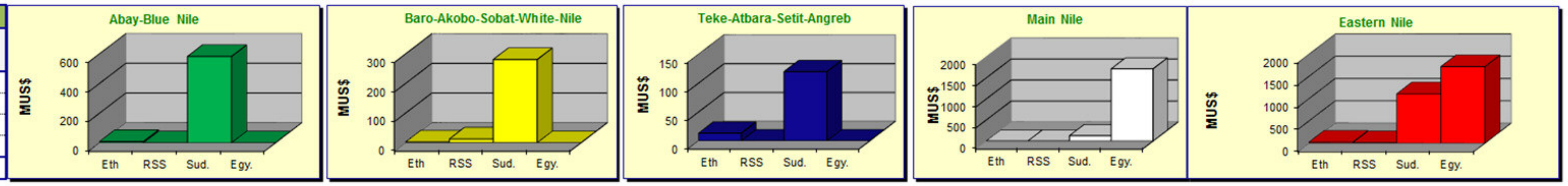
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1	0	10	0	11
BAS-White Nile	0	0	2	0	3
Tekeze-Atbara	1	0	2	0	2
Main Nile	0	0	1	53	54
EN-Total	1	0	16	53	70



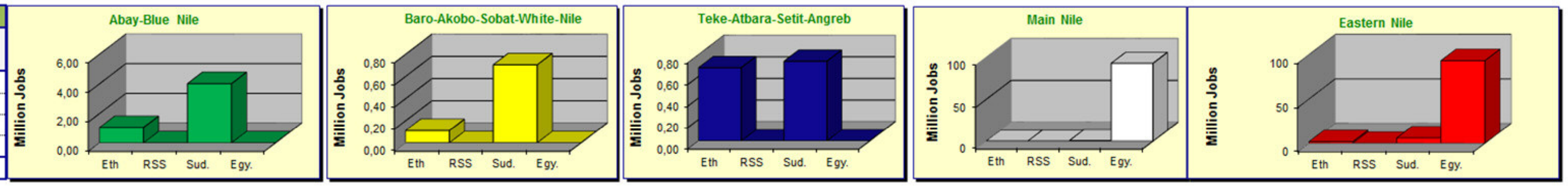
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	23	0	1 134	0	1 157
BAS-White Nile	5	23	523	0	552
Tekeze-Atbara	30	0	230	0	259
Main Nile	0	0	242	3 562	3 804
EN-Total	58	23	2 129	3 562	5 772



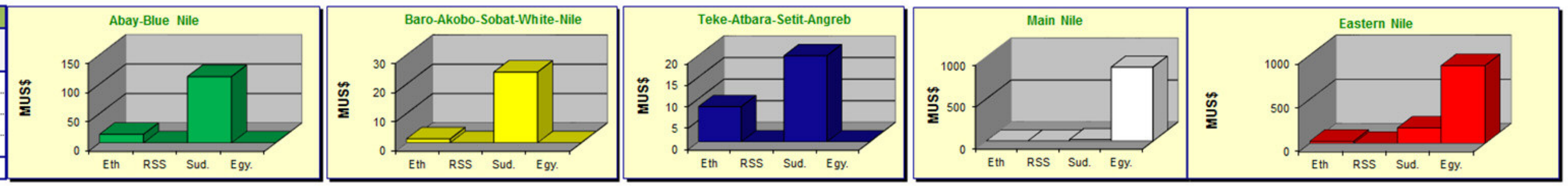
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	9	0	581	0	590
BAS-White Nile	2	13	281	0	296
Tekeze-Atbara	13	0	120	0	133
Main Nile	0	0	129	1 718	1 847
EN-Total	25	13	1 111	1 718	2 866



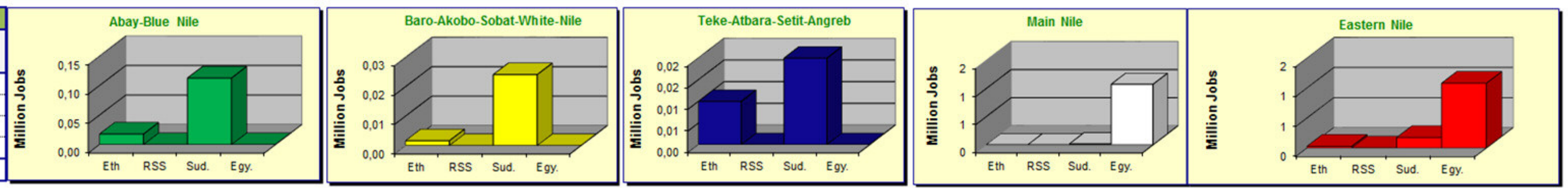
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1,05	0,00	4,01	0,00	5
BAS-White Nile	0,11	0,00	0,70	0,00	1
Tekeze-Atbara	0,68	0,00	0,74	0,00	1
Main Nile	0,00	0,00	0,67	92,99	94
EN-Total	1,84	0,00	6,13	92,99	101



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	15	0	113	0	127
BAS-White Nile	1	0	24	0	25
Tekeze-Atbara	8	0	20	0	28
Main Nile	0	0	18	881	899
EN-Total	24	0	175	881	1 080



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,11	0,00	0,13
BAS-White Nile	0,00	0,00	0,02	0,00	0,03
Tekeze-Atbara	0,01	0,00	0,02	0,00	0,03
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,03	0,00	0,17	1,08	1,28



3.2.6 **Scenario 6 – IS + Large Irrigation Potential**

3.2.6.1 Introduction

In Scenario 5 curtailment of full irrigation potential had been applied. This meant that only large scale irrigation schemes that were either advanced to feasibility or pre-feasibility level were considered (IS)together with the (almost) full implementation of hydropower potential. In Scenario 6 the **large expansion of irrigation is investigated, coupled with only IS development of hydropower.** It could be argued that this is a reflection of country priorities pertaining to irrigated agriculture. It differs from Scenario 4 which was more extreme, assuming the implementation of full irrigation potential.

Once again it can be clearly observed from Table 3-10 there is a deficit of about 9 BCM (compared to a deficit of 19 BCM for Scenario 4) to meet the irrigation demand of large scale irrigation potential in the EN.

Table 3-10: Summary of water resources results for Scenario 6.

Water Budget	Baseline	Scenario 6	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**115**	***32%***
Per major economic sector			***Share***
Irrigation+Domestic+Livestocks	*67*	*93*	*81%*
Hydropower & Evaporation losses	*20*	*22*	*19%*
Per country			***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*68*	*59%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*13*	*11%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*32*	*28%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	47,0
Blue Nile at Khartoum	53,6	44,6	30,7
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	23,3
White Nile at Mogren	28,7	25,7	18,5
Main Nile at Hassanab	82,4	69,7	48,5
Atbara Kilo -3	11,4	8,1	11,0
Main Nile US Aswan	96,7	78,5	55,8
Main Nile US Delta	93,0	43,1	43,1
Drainage to Mediterranean Sea	0,0	12,6	-9,0

3.2.6.2 Economic analysis

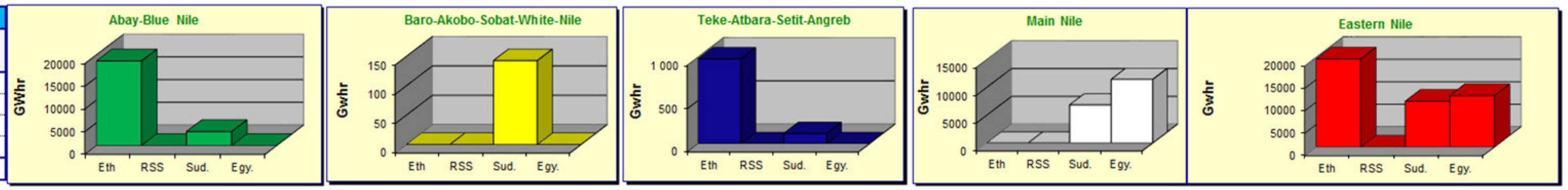
Table 3-11 summarizes the main results of scenario 4 in terms of cost, benefits, social and environmental externalities, employment and food security. Since this scenario is not viable because of constraint in water availability, detailed presentation of the economic results were not shown.

Table 3-11: Summary of the economic results for Scenario 6 : IS + Large Irrigation Potential

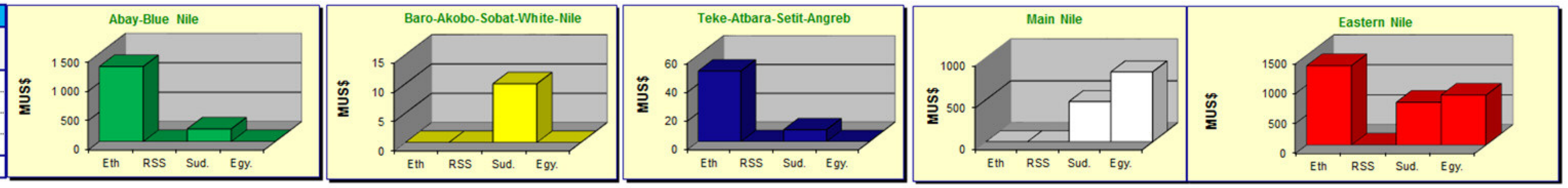
Economic & Social Indicators	Baseline	Scenario 6	Comparison
Total HP generated (annual average production, in GWh)	**21 721**	41 254	*90%*
Total irrigation area (in 1000 ha)	**6 744**	8 370	*24%*
Water storage requirements (in BCM)	**209**	286	*37%*
Total Revenue Generated (in Million US$)	**4946**	7971	*61%*
			Sector Share
Hydrpower	*1652*	***2870***	***36%***
Irrigated Agriculture	*2254*	***4055***	***51%***
Livestock Associated with Irrigation	*990*	***990***	***12%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***56***	***1%***
Total Employment Generated (in Million Jobs)	**101**	115	*14%*
			Sector Share
Irrigated Agriculture	*99*	***114***	***98,57%***
Livestock Associated with Irrigation	*2*	***2***	***1,38%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,06%***
Total Investment Cost (in Million US$)		**40 253**	
Net Present Value NPV: (in Million US$)		**40 424**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)		**Irrigation (US Cents/m3)**	
13,34		4,36	

Figure 3-6: Summary of economic results for Scenario 6: Improved situation (IS) + large irrigation potential

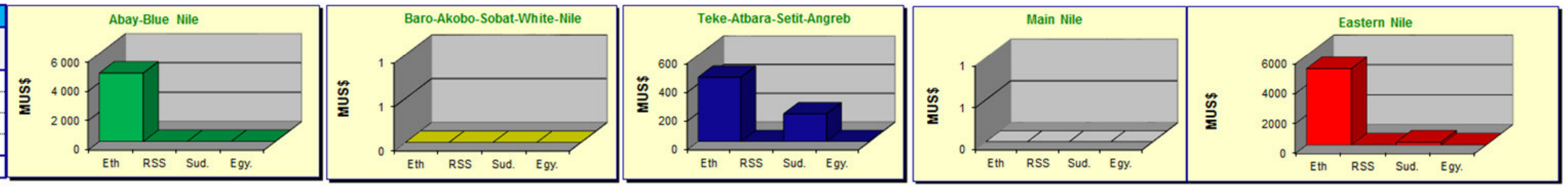
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	18 623	0	3 066	0	21 689
BAS-White Nile	0	0	143	0	143
Tekeze-Atbara	981	0	118	0	1 099
Main Nile	0	0	6 866	11 457	18 323
EN-Total	19 604	0	10 193	11 457	41 254



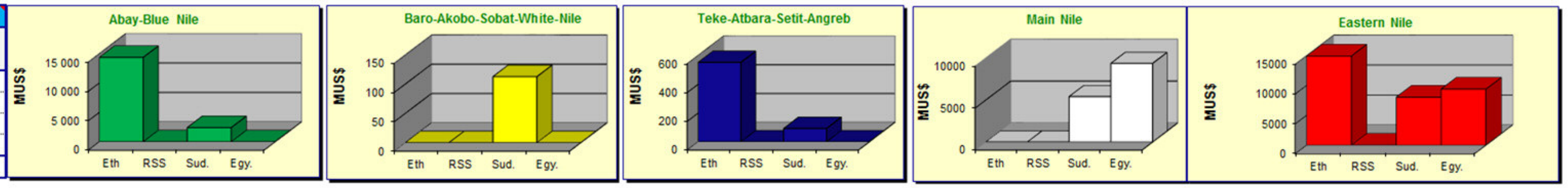
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1 275	0	215	0	1 490
BAS-White Nile	0	0	10	0	10
Tekeze-Atbara	49	0	8	0	57
Main Nile	0	0	481	833	1 313
EN-Total	1 324	0	714	833	2 870



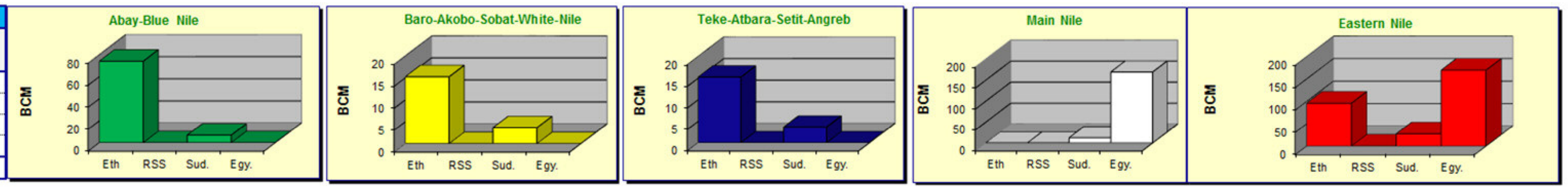
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	4 652	0	0	0	4 652
BAS-White Nile	0	0	0	0	0
Tekeze-Atbara	447	0	193	0	640
Main Nile	0	0	0	0	0
EN-Total	5 099	0	193	0	5 292



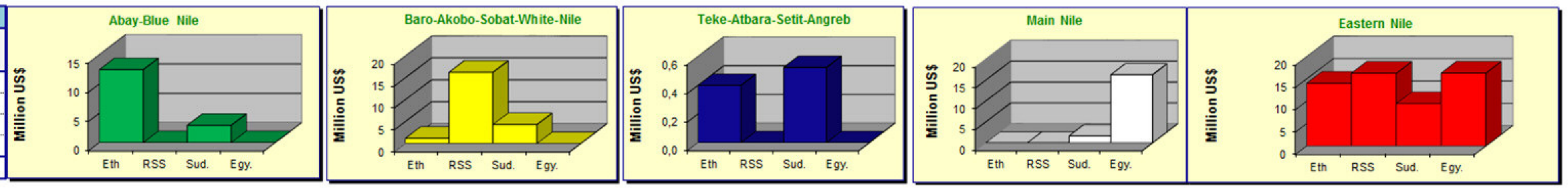
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	14 354	0	2 416	0	16 770
BAS-White Nile	0	0	113	0	113
Tekeze-Atbara	552	0	93	0	645
Main Nile	0	0	5 411	9 373	14 784
EN-Total	14 906	0	8 033	9 373	32 312



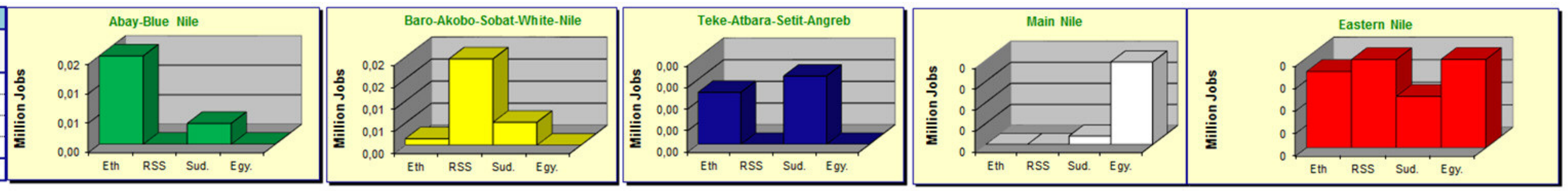
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	74	0	7	0	81
BAS-White Nile	7	0	5	0	5
Tekeze-Atbara	15	0	4	0	19
Main Nile	0	0	12	169	182
EN-Total	96	0	28	169	286



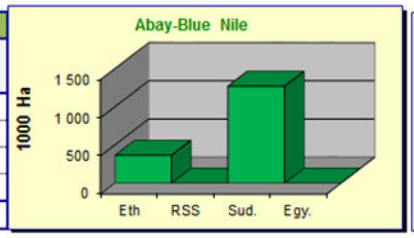
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	12	0	3	0	15
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	0	0	1	0	1
Main Nile	0	0	2	16	18
EN-Total	14	16	9	16	56

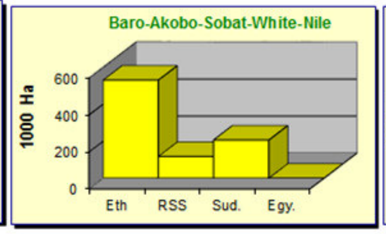


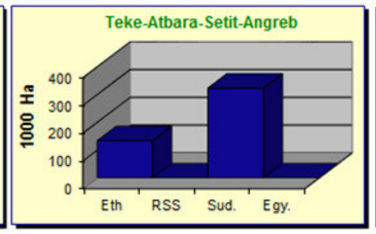
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,01	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07

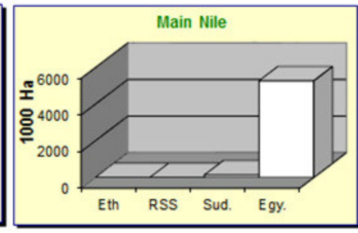


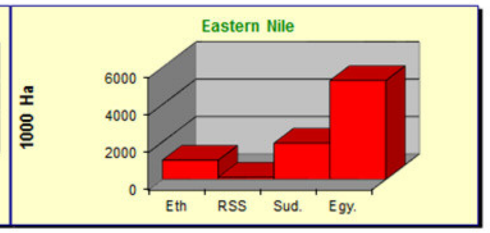
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	364	0	1 268	0	**1 632**
BAS-White Nile	530	118	206	0	**854**
Tekeze-Atbara	135	0	323	0	**458**
Main Nile	0	0	142	5 285	**5 427**
EN-Total	**1 028**	**118**	**1 939**	**5 285**	**8 370**



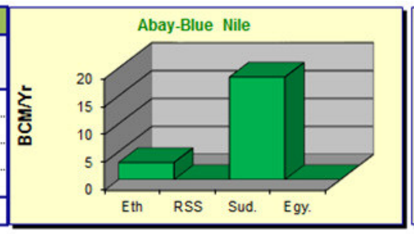


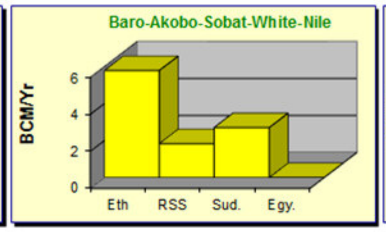


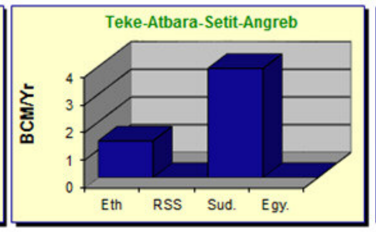


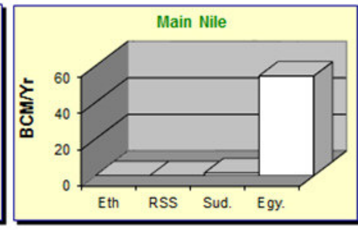


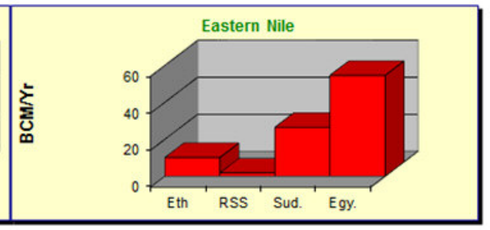
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	3	0	18	0	**21**
BAS-White Nile	6	2	3	0	**10**
Tekeze-Atbara	1	0	4	0	**5**
Main Nile	0	0	1	55	**56**
EN-Total	**10**	**2**	**26**	**55**	**93**



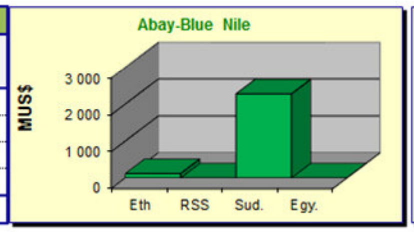


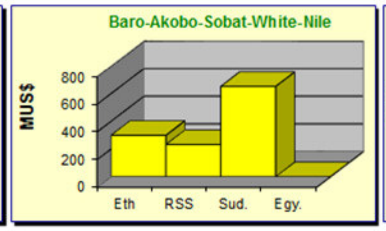


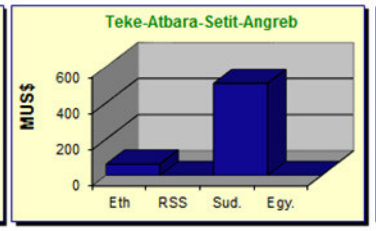


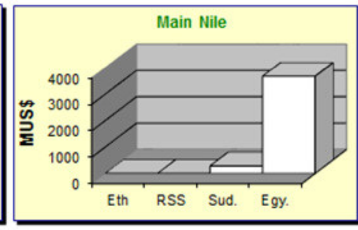


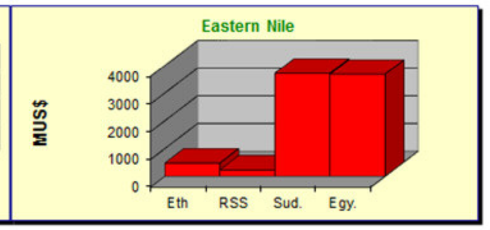
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	119	0	2 273	0	**2 392**
BAS-White Nile	299	232	652	0	**1 183**
Tekeze-Atbara	63	0	508	0	**571**
Main Nile	0	0	284	3 683	**3 967**
EN-Total	**481**	**232**	**3 717**	**3 683**	**8 113**



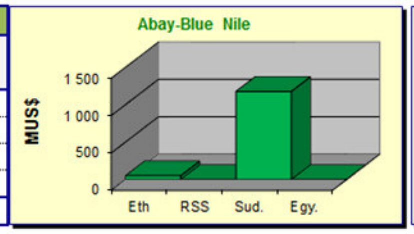


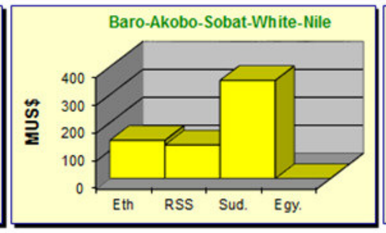


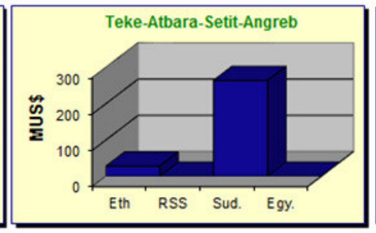


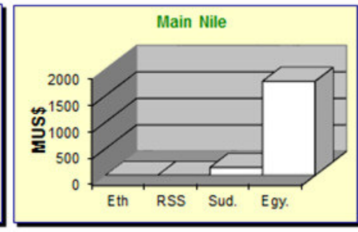


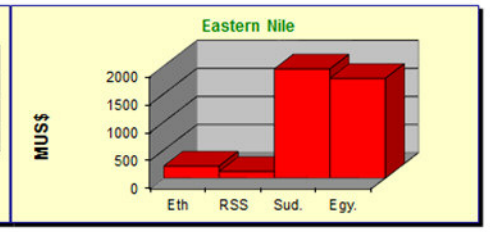
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	50	0	1 177	0	**1 228**
BAS-White Nile	137	120	351	0	**608**
Tekeze-Atbara	28	0	264	0	**292**
Main Nile	0	0	152	1 775	**1 927**
EN-Total	**216**	**120**	**1 944**	**1 775**	**4 055**



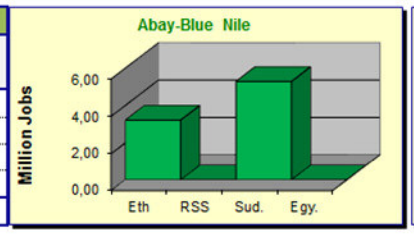


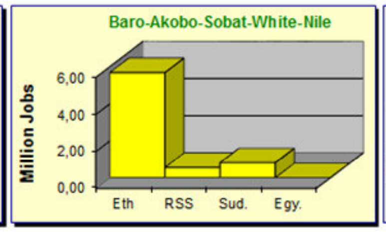


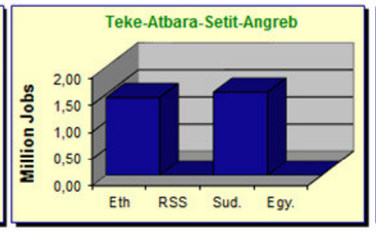


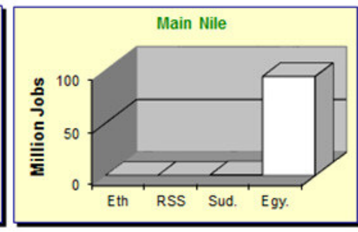


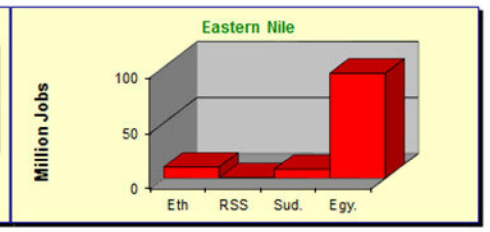
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	3,22	0,00	5,29	0,00	**9**
BAS-White Nile	5,68	0,56	0,82	0,00	**7**
Tekeze-Atbara	1,44	0,00	1,54	0,00	**3**
Main Nile	0,00	0,00	0,67	94,38	**95**
EN-Total	**10,34**	**0,56**	**8,32**	**94,38**	**114**



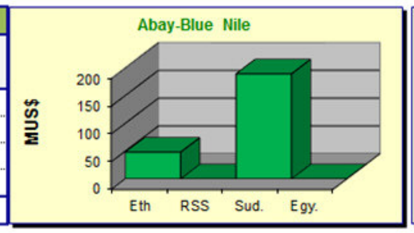


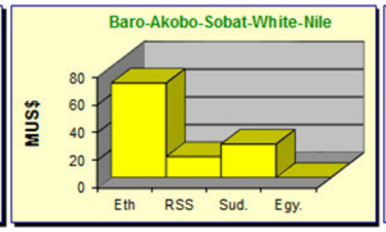


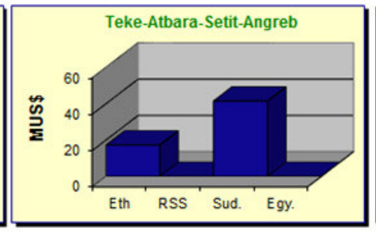


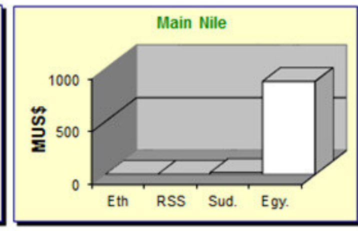


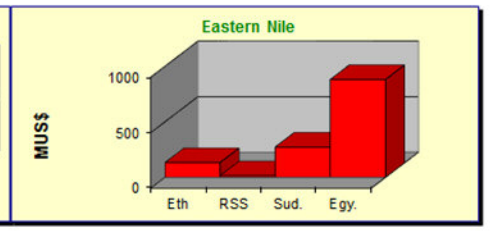
Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	48	0	189	0	**237**
BAS-White Nile	68	15	24	0	**107**
Tekeze-Atbara	17	0	42	0	**59**
Main Nile	0	0	18	881	**899**
EN-Total	**133**	**15**	**273**	**881**	**1 302**



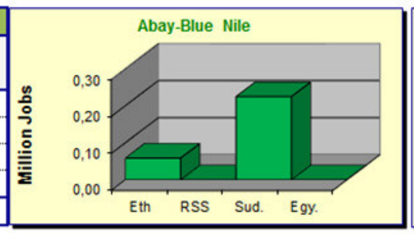


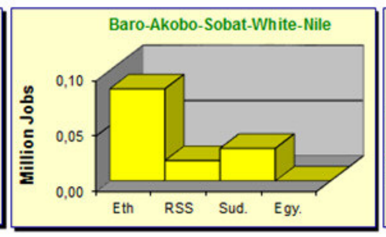


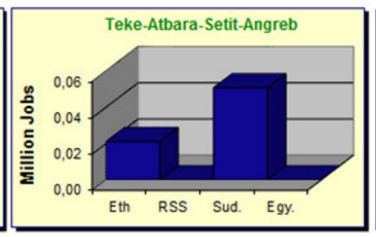


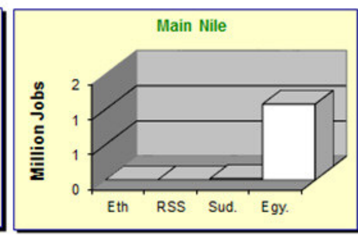


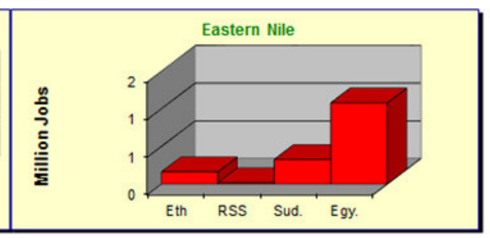
Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,06	0,00	0,22	0,00	**0,28**
BAS-White Nile	0,08	0,02	0,03	0,00	**0,13**
Tekeze-Atbara	0,02	0,00	0,05	0,00	**0,07**
Main Nile	0,00	0,00	0,02	1,08	**1,10**
EN-Total	**0,16**	**0,02**	**0,33**	**1,08**	**1,59**











3.2.7 **Scenario 7a – IS+Large Hydro+Large Irrigation in BAS +TZA**

3.2.7.1 Introduction

This scenario consider the comparative advantage of development in the different EN sub-basins. In a wat it evaluate the trade-off of hydro versus irrigation in the Abay-Blue Nile and explore potential of irrigation development for the upper riparian states in the basin (specifically Ethiopia and South Sudan in BAS) without causing significant harm to downstream users. In addition the scenario consider large scale irrigation development in Tekeze Atbara sub-basin. Namely Angreb, Metema, Humera in Ethiopia and Upper Atbara in Sudan.

3.2.7.2 Water resources analysis

Table 3-12 present the water budget for Scenario 7 compared to the base-case.

Table 3-12 : Summary of water resources results for Scenario 7-a

Water Budget	**Baseline**	**Scenario 7a**	***Comparison***
Total Water Uses (in BCM/yr)	**87**	**104**	***20%***
Per major economic sector			***Share***
Irrigation+Domestic+Livestocks	*67*	*80*	*77%*
Hydropower & Evaporation losses	*20*	*24*	*23%*
Per country			***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*63%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*12*	*12%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*24*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	49,2
Blue Nile at Khartoum	53,7	44,6	41,1
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,7
White Nile at Mogren	28,7	25,7	18,5
Main Nile at Hassanab	82,4	69,7	57,0
Atbara Kilo -3	11,4	7,8	11,0
Main Nile US Aswan	96,7	78,5	62,0
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	-0,8

The White Nile flows at Malkal is reduced from 29.7 BCM to 23.3 BCM. This is attributed to the planned 0.65 million ha in BAS. The flows at Atbara Kilo-3 is reduced from 11.4 BCM to 7.8 BCM. The 3.6 BCM losses in Atbara annual yield at Kilo-3 is due to irrigation expansion upstream. Despite the fact that, there is still about 0.8 BCM of deficit in water, this scenario worth further exploration by studying potentials for water savings through coordinated planning and operation of existing and proposed storage reservoirs.

3.2.7.3 Economic analysis

Table 3-13 summarises the main results of Scenario 7 in terms of cost, benefits, social and environmental externalities, employment and food security. It worth mentioning that this scenario capture the interest of South Sudan in having some sort of equitable share in the benefit from the EN.

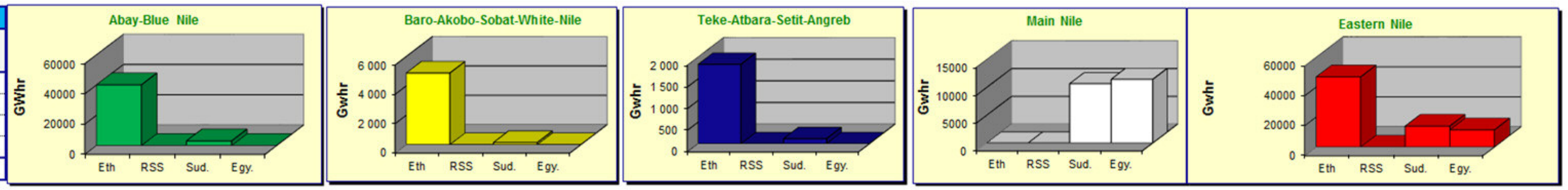
- the NPV over the 30 years horizon of the evaluation is about 181 Billion US$.
- Based on the above potential irrigation investment in BAS seems to be economically attractive and have lesser impact to downstream users than Abay or Tekeze. However the proposed huge irrigation area might have significant impact on the wetlands systems in BAS. Hence detailed environmental assessments should be explored.

Table 3-13: Summary of the economic results for Scenario 7-a

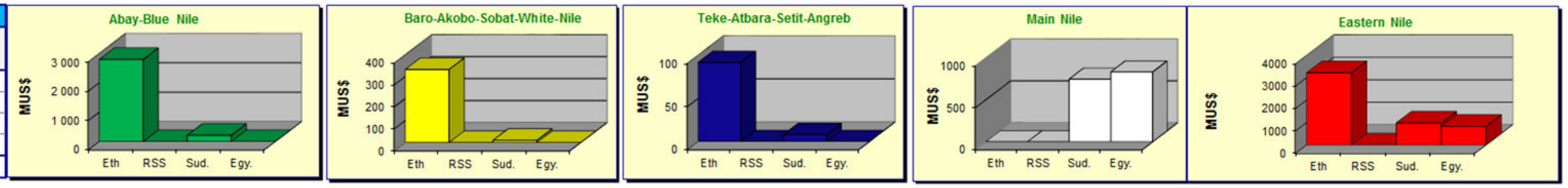
Economic & Social Indicators	Baseline	Scenario 7a	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	72 290	*233%*
Total irrigation area (in 1000 ha)	**6 744**	7 667	*14%*
Water storage requirements (in BCM)	**209**	389	*86%*
Total Revenue Generated (in Million US$)	**4946**	9417	*90%*
			Sector Share
Hydrpower	*1652*	***5029***	***53%***
Irrigated Agriculture	*2254*	***3338***	***35%***
Livestock Associated with Irrigation	*990*	***990***	***11%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***61***	***1%***
Total Employment Generated (in Million Jobs)	**101**	110	*9%*
			Sector Share
Irrigated Agriculture	*99*	***109***	***98,64%***
Livestock Associated with Irrigation	*2*	***1***	***1,30%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**38 244**	
Net Present Value NPV: (in Million US$)		**63 325**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
21,36	4,15		

Figure 3-7: Summary of economic results for Scenario 7a: Improved situation (IS) +Large Hydropower potential +Large Irrigation in BAS +TZA

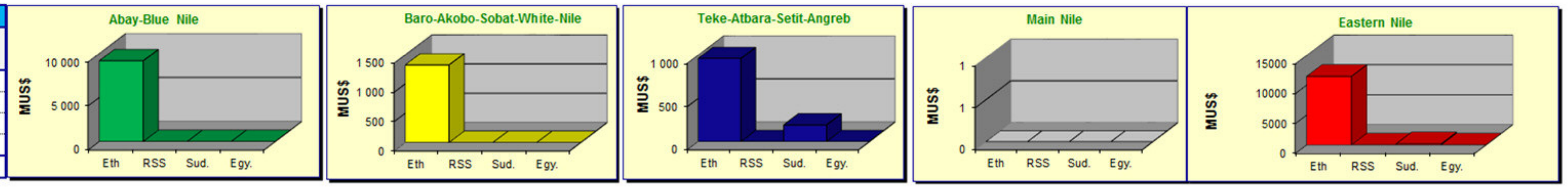
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	40 131	0	3 066	0	43 197
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	10 667	11 457	22 124
EN-Total	46 839	0	13 994	11 457	72 290



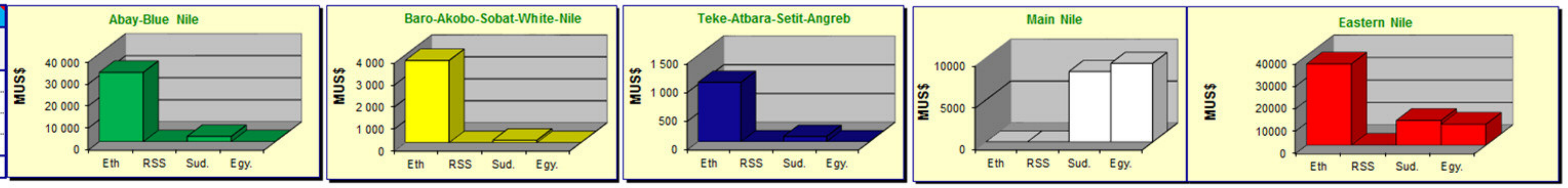
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2 793	0	215	0	3 007
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	747	833	1 579
EN-Total	3 216	0	980	833	5 029



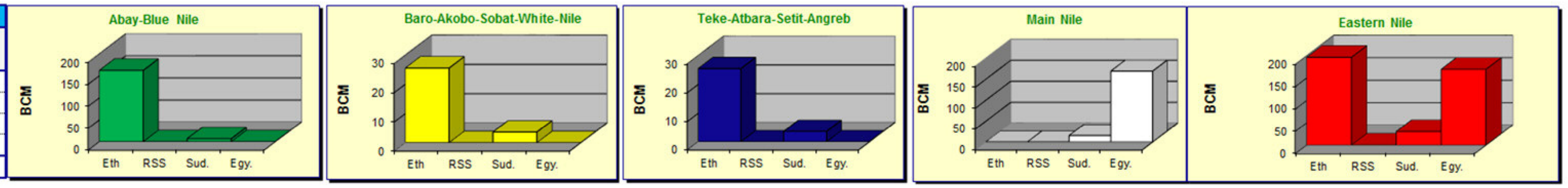
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	9 159	0	0	0	9 159
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	11 445	0	193	0	11 638



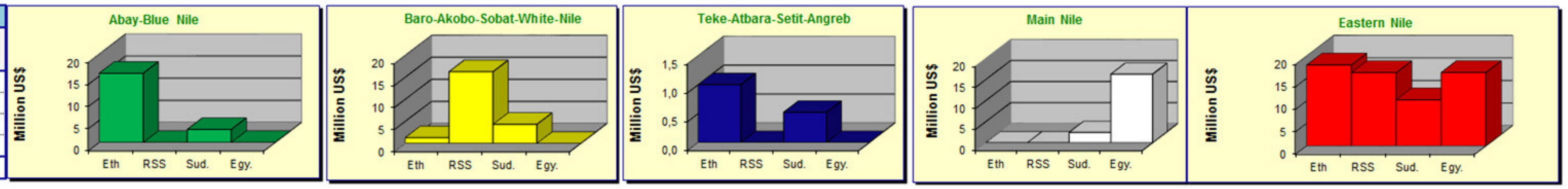
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	31 439	0	2 416	0	33 855
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	8 406	9 373	17 779
EN-Total	36 210	0	11 028	9 373	56 610



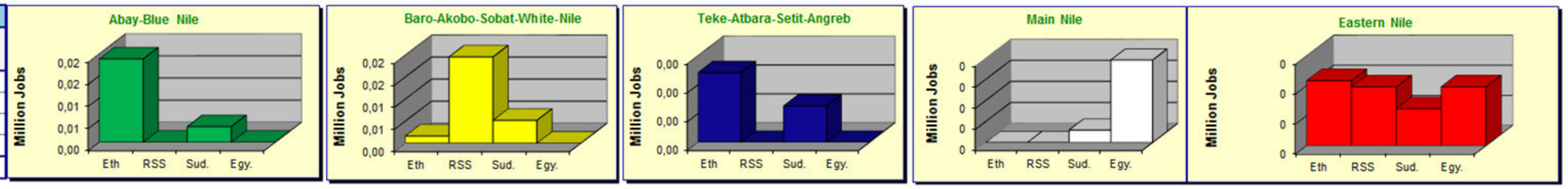
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	162	0	7	0	169
BAS-White Nile	8	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	15	169	185
EN-Total	196	0	31	169	389



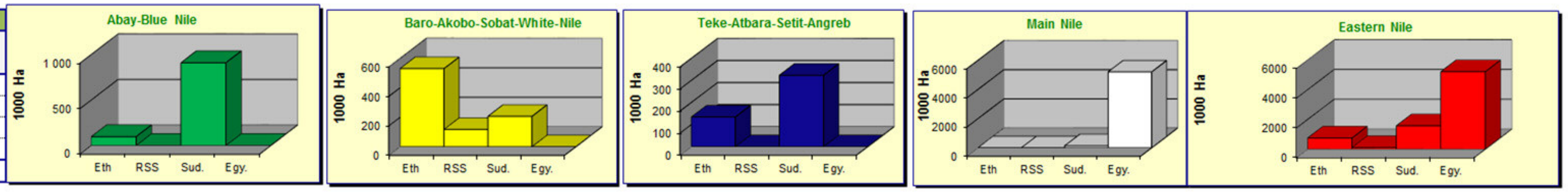
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	16	0	3	0	19
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	19
EN-Total	18	16	10	16	61



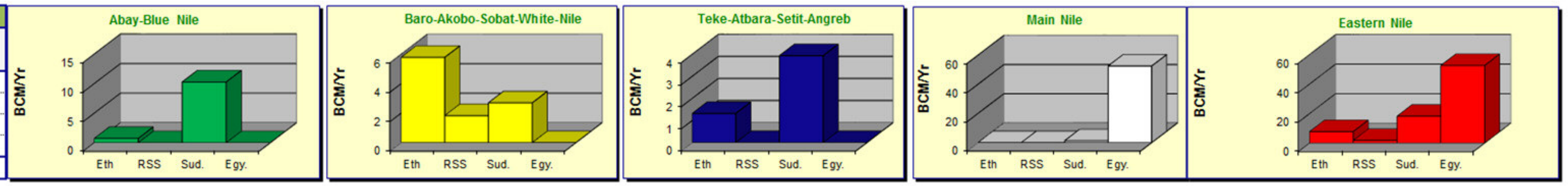
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



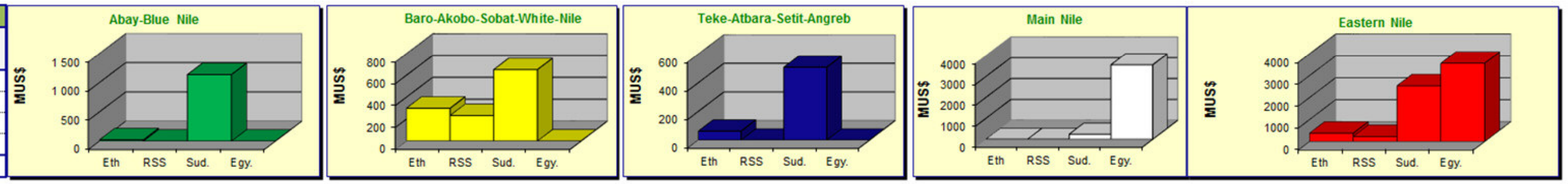
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	98	0	909	0	1 007
BAS-White Nile	530	118	206	0	854
Tekeze-Atbara	135	0	323	0	458
Main Nile	0	0	142	5 207	5 349
EN-Total	762	118	1 580	5 207	7 667



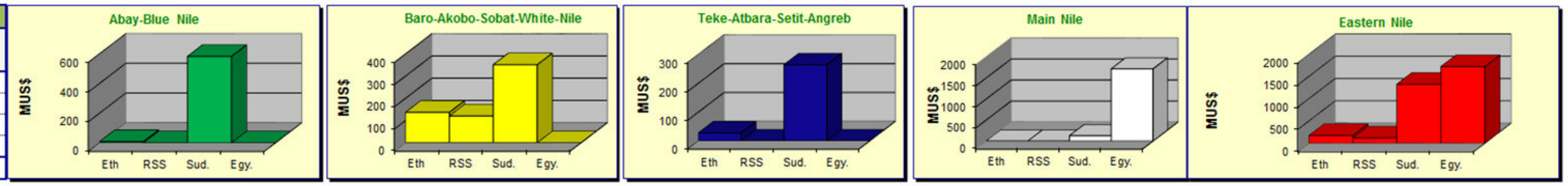
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	1	0	10	0	11
BAS-White Nile	6	2	3	0	10
Tekeze-Atbara	1	0	4	0	5
Main Nile	0	0	1	53	54
EN-Total	8	2	18	53	80



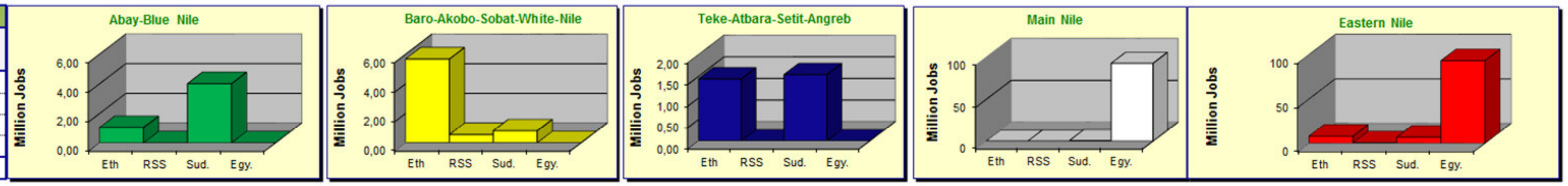
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	23	0	1 134	0	1 157
BAS-White Nile	299	232	652	0	1 183
Tekeze-Atbara	63	0	508	0	571
Main Nile	0	0	242	3 562	3 804
EN-Total	385	232	2 536	3 562	6 715



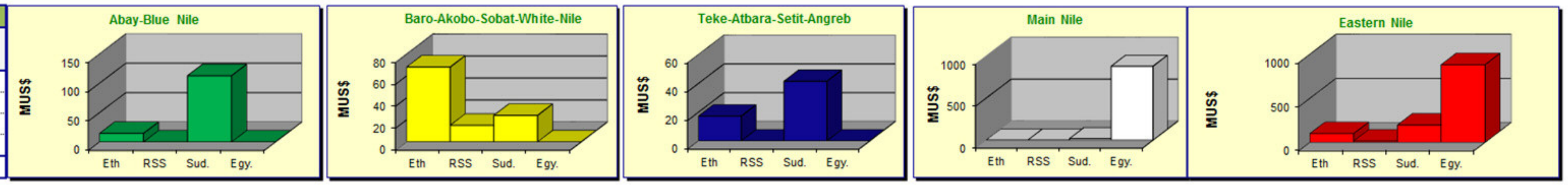
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	9	0	581	0	590
BAS-White Nile	137	120	351	0	608
Tekeze-Atbara	28	0	264	0	292
Main Nile	0	0	129	1 718	1 847
EN-Total	174	120	1 325	1 718	3 338



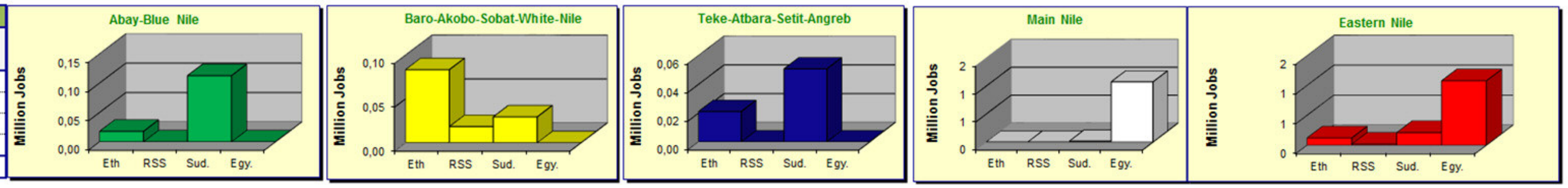
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	1,05	0,00	4,01	0,00	5
BAS-White Nile	5,68	0,56	0,82	0,00	7
Tekeze-Atbara	1,44	0,00	1,54	0,00	3
Main Nile	0,00	0,00	0,67	92,99	94
EN-Total	8,17	0,56	7,04	92,99	109



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	15	0	113	0	127
BAS-White Nile	68	15	24	0	107
Tekeze-Atbara	17	0	42	0	59
Main Nile	0	0	18	881	899
EN-Total	100	15	196	881	1 192



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	0,02	0,00	0,11	0,00	0,13
BAS-White Nile	0,08	0,02	0,03	0,00	0,13
Tekeze-Atbara	0,02	0,00	0,05	0,00	0,07
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,12	0,02	0,21	1,08	1,43



3.2.8 **Scenario 7b – Large Hydro+IS in BAS +TZA and Large irrigation development in Sudan**

3.2.8.1 Introduction

This scenario consider IS irrigation level in BAS and Tekeze while looking at large developement irrigation in Sudan.

3.2.8.2 Water resources analysis

The table below presents the water budget for scenario 7b compared to the base-case. Water users is about 2 BCM more than uses in 7a, and as a results it laeds to about 2 BCM deficit.

Table 3-14 : Summary of water resources results for Scenario 7b

Water Budget	**Baseline**	**Scenario 7b**	***Comparison***
Total Water Uses (in BCM/yr)	**87**	**106**	***22%***
Per major economic sector			***Share***
Irrigation+Domestic+Livestocks	*67*	*83*	*78%*
Hydropower & Evaporation losses	*20*	*23*	*22%*
Per countryr			***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*62%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*6*	*6%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*32*	*30%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	48,1
Blue Nile at Khartoum	53,7	44,6	31,2
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	29,0
White Nile at Mogren	28,7	25,7	24,3
Main Nile at Hassanab	82,4	69,7	54,5
Atbara Kilo -3	14.3	8,1	11,0
Main Nile US Aswan	96,7	78,5	59,9
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	-3,0

3.2.8.3 Economic analysis

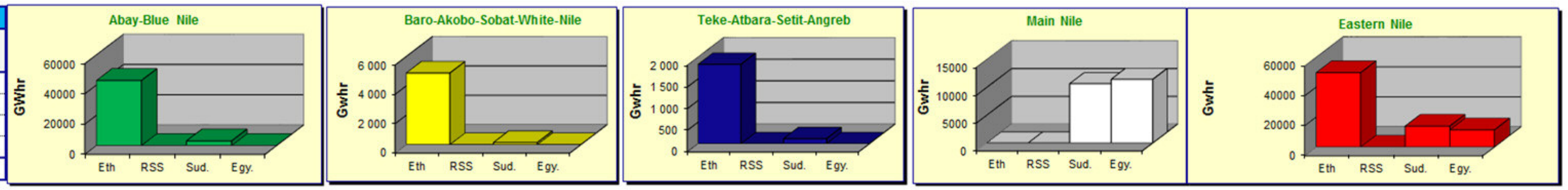
The following page summarizes the main results of scenario 7b in terms of cost, benefits, social and environmental externalities, employment and food security.

Table 3-15: Summary of the economic results for Scenario 7b

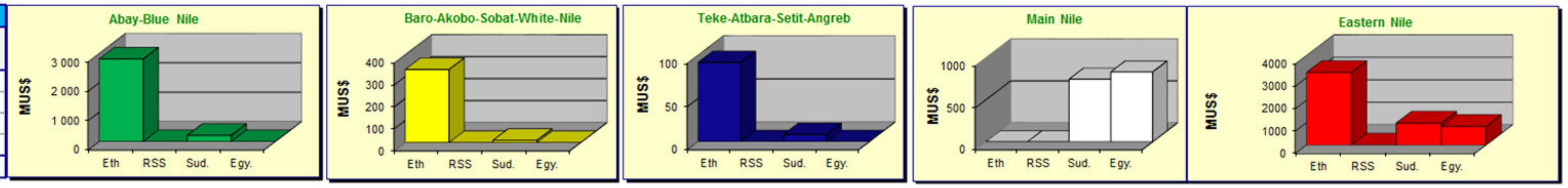
Economic & Social Indicators	Baseline	Scenario 7b	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	75 133	*246%*
Total irrigation area (in 1000 ha)	**6 744**	7 479	*11%*
Water storage requirements (in BCM)	**209**	397	*90%*
Total Revenue Generated (in Million US$)	**4946**	9892	*100%*
			Sector Share
Hydrpower	*1652*	***5048***	***51%***
Irrigated Agriculture	*2254*	***3793***	***38%***
Livestock Associated with Irrigation	*990*	***990***	***10%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***60***	***1%***
Total Employment Generated (in Million Jobs)	**101**	105,7	*5,0%*
			Sector Share
Irrigated Agriculture	*99*	***104***	***98,55%***
Livestock Associated with Irrigation	*2*	***1***	***1,38%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**40 267**	
Net Present Value NPV: (in Million US$)		**64 380**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
21,65	4,59		

Figure 3-8: Summary of economic results for Scenario 7b: Large Hydro+IS in BAS +TZA and Large irrigation development in Sudan

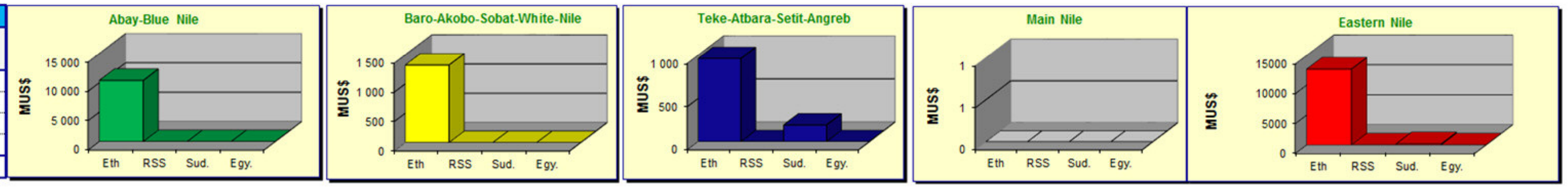
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	42 974	0	3 066	0	46 040
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	10 667	11 457	22 124
EN-Total	49 682	0	13 994	11 457	75 133



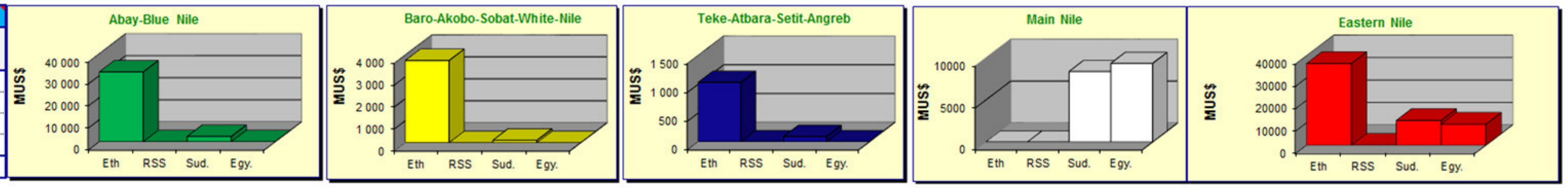
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	2 812	0	215	0	3 027
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	747	833	1 579
EN-Total	3 236	0	980	833	5 048



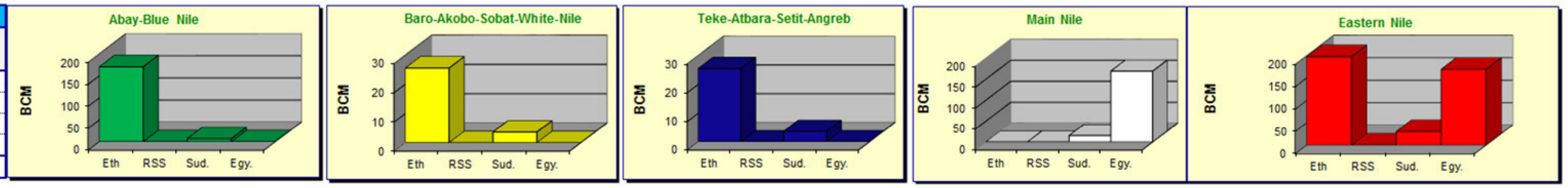
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	10 389	0	0	0	10 389
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	12 675	0	193	0	12 868



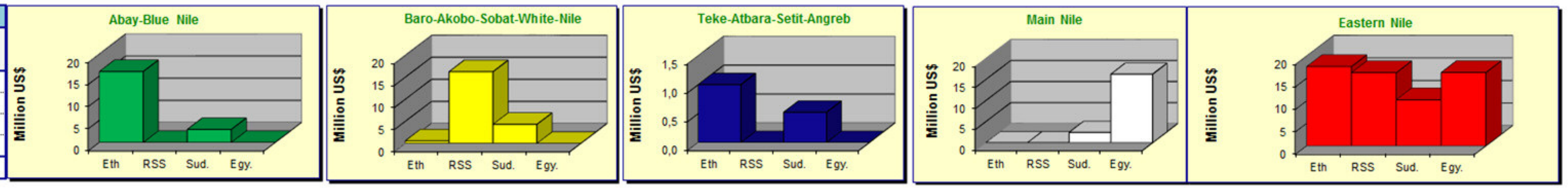
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	31 662	0	2 416	0	34 078
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	8 406	9 373	17 779
EN-Total	36 433	0	11 028	9 373	56 833



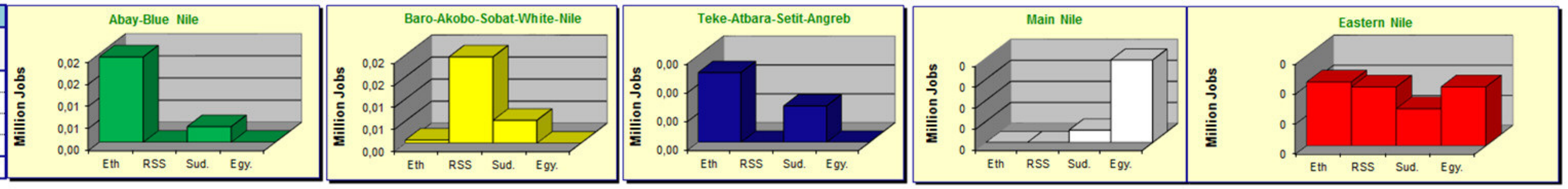
Storage Requirements: (BCM /yr))					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	170	0	7	0	177
BAS-White Nile	1	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	15	169	185
EN-Total	197	0	31	169	397



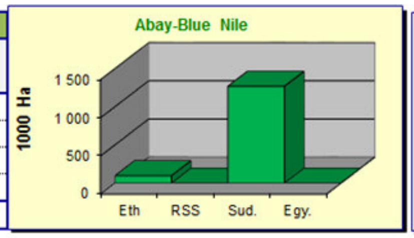
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	16	0	3	0	19
BAS-White Nile	1	16	4	0	21
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	19
EN-Total	18	16	10	16	60

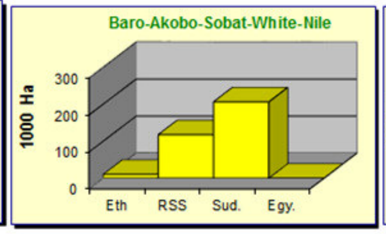


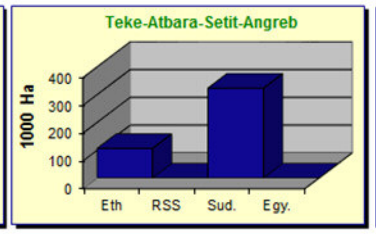
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07

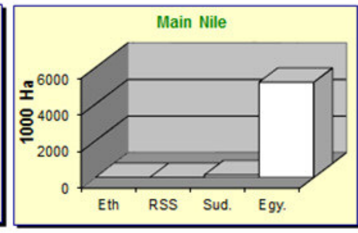


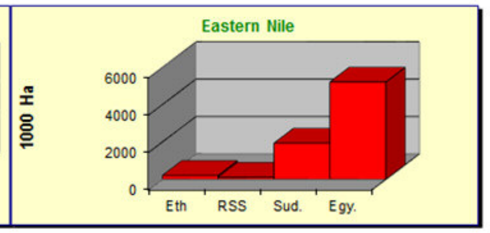
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	98	0	1 268	0	1 366
BAS-White Nile	10	118	206	0	334
Tekeze-Atbara	106	0	323	0	430
Main Nile	0	0	142	5 207	5 349
EN-Total	215	118	1 939	5 207	7 479



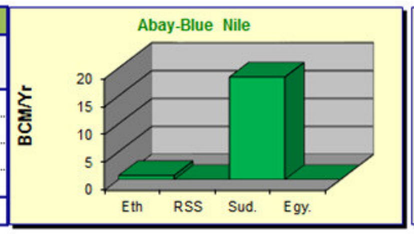


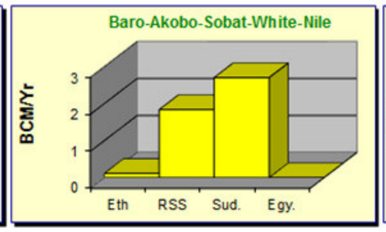


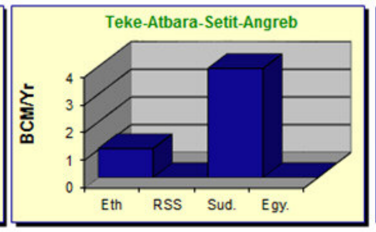


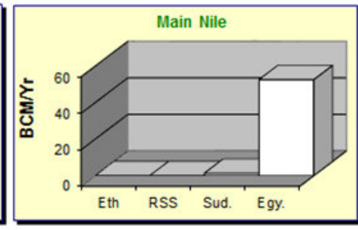


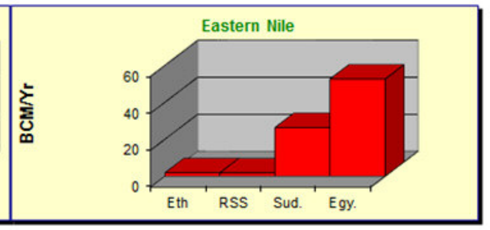
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	1	0	18	0	19
BAS-White Nile	0	2	3	0	5
Tekeze-Atbara	1	0	4	0	5
Main Nile	0	0	1	53	54
EN-Total	2	2	26	53	83



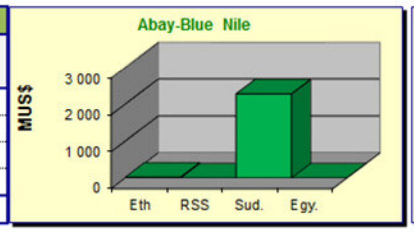


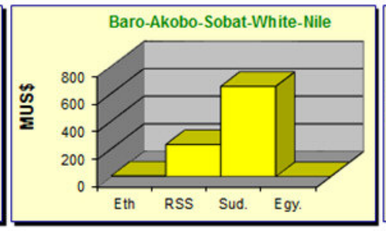


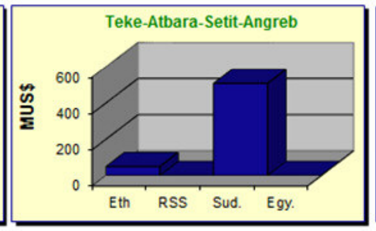


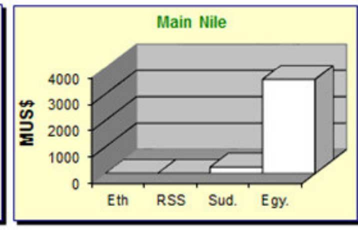


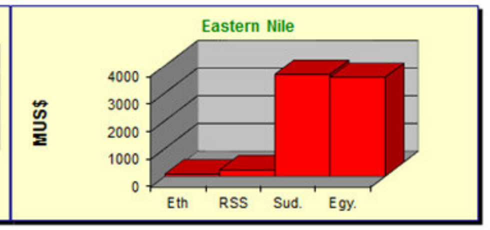
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	23	0	2 273	0	2 296
BAS-White Nile	5	232	652	0	889
Tekeze-Atbara	50	0	508	0	558
Main Nile	0	0	242	3 562	3 804
EN-Total	78	232	3 675	3 562	7 547



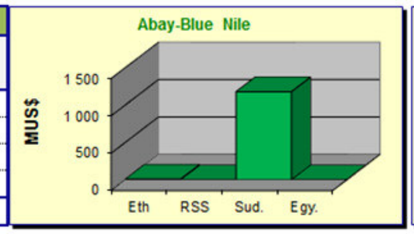


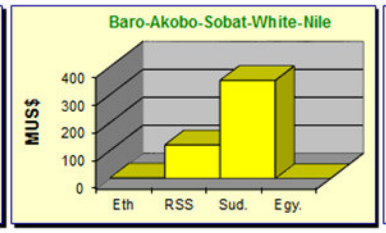


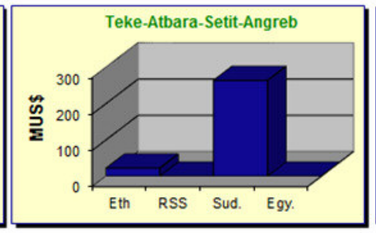


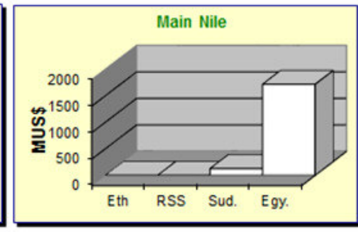


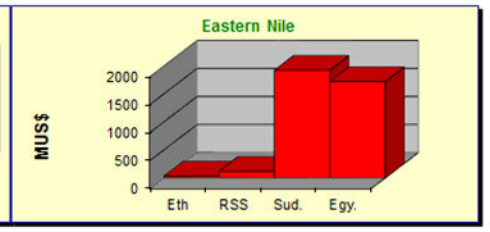
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	9	0	1 177	0	1 186
BAS-White Nile	2	120	351	0	474
Tekeze-Atbara	22	0	264	0	286
Main Nile	0	0	129	1 718	1 847
EN-Total	34	120	1 921	1 718	3 793



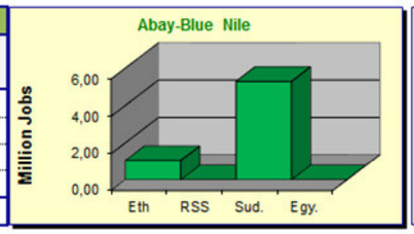


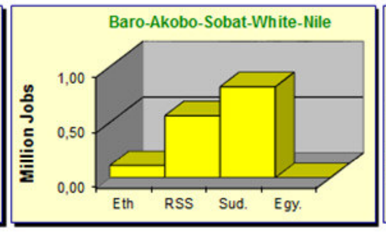


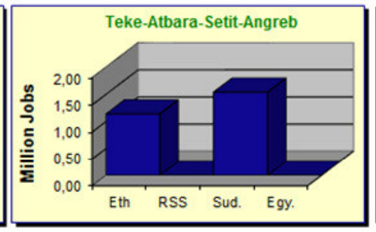


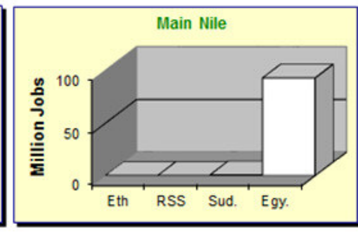


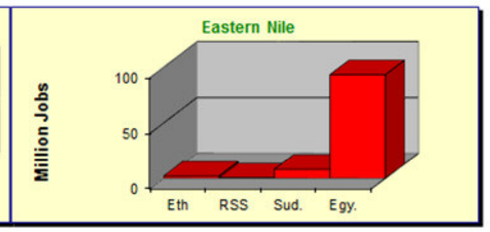
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	1,05	0,00	5,29	0,00	6
BAS-White Nile	0,11	0,56	0,82	0,00	1
Tekeze-Atbara	1,14	0,00	1,54	0,00	3
Main Nile	0,00	0,00	0,67	92,99	94
EN-Total	2,30	0,56	8,32	92,99	104



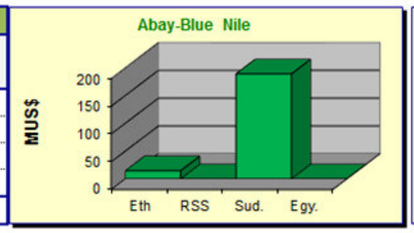


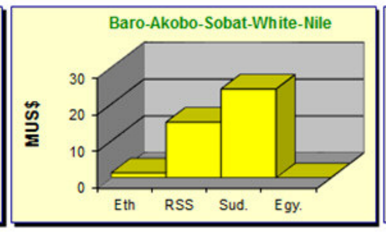


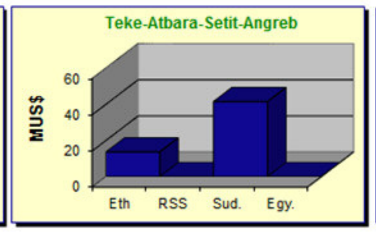


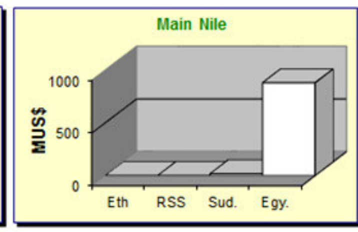


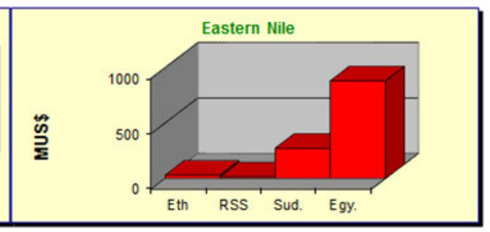
Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	15	0	189	0	204
BAS-White Nile	1	15	24	0	41
Tekeze-Atbara	14	0	42	0	55
Main Nile	0	0	18	881	899
EN-Total	30	15	273	881	1 198



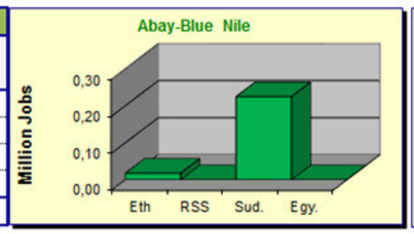


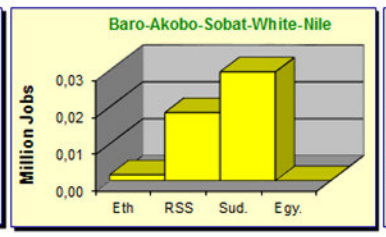


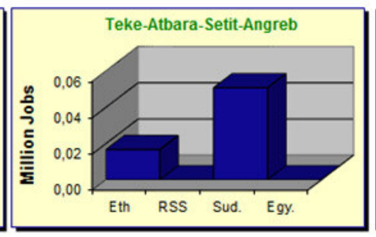


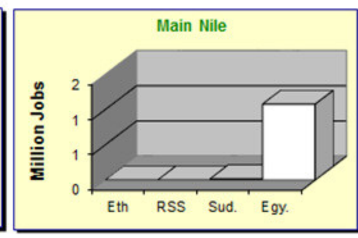


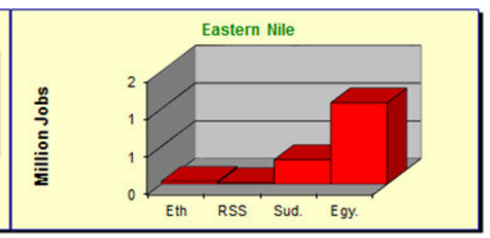
Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth	RSS	Sud.	Egy.	Total
	0	0	0	0	0
Abay-Blue Nile	0,02	0,00	0,22	0,00	0,24
BAS-White Nile	0,00	0,02	0,03	0,00	0,05
Tekeze-Atbara	0,02	0,00	0,05	0,00	0,07
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,04	0,02	0,32	1,08	1,46











3.2.9 Scenario 8a – IS + Large Hydro+ Moderate Irrig.

3.2.9.1 Introduction

The targeted irrigation developments on the Abay-BN are: Lake Tana, Beles, Arjo Didedessa on the Ethiopia side and the Sudan side the Great Kenana and Rahad II. On the Baro-Akobo Sobat all the schemes identified along the Baro River were considered in addition to Gilo-2 Right and left banks. In addition the newly identified potential on Baro at Itang Pibor and Sobat river systems were also considered. On Tekeze, both Metema and Humera were considered.

3.2.9.2 Water resources analysis

Table 3-16 shows the water budget as the results of implementing scenario 8a.

Table 3-16: Summary of water resources results for scenario 8a

Water Budget	Baseline	Scenario 8a	Comparison
Total Water Uses (in BCM/yr)	**87**	**108**	***24%***
Per major economic sector			***Share***
Irrigation+Domestic+Livestocks	*67*	*84*	*78%*
Hydropower & Evaporation losses	*20*	*23*	*22%*
Per countryr			***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*68*	*63%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*14*	*13%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*25*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 8a***
Abay-Blue Nile at Kessie	16,6	16,5	16,1
Blue Nile at Deim	49,7	49,4	46,0
Blue Nile at Khartoum	53,7	44,6	35,0
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	23,3
White Nile at Mogren	28,7	25,7	19,2
Main Nile at Hassanab	82,4	69,7	53,5
Atbara Kilo -3	14,3	8,3	11,0
Main Nile US Aswan	96,7	78,5	61,1
Main Nile US Delta	93,0	43,1	43,1
Drainage to Medditeranean Sea	0,0	12,6	-3,3

The implications of pursuing the above mentioned irrigation expansions is a reduction in the flow at Aswan to 61.1 BCM/Yr. This scenario integrate country priority as well as provision for South Sudan irrigation development of about 0.12 million ha in Pibor and Sobat. Hence the viability of implementing this scenario on the medium to long-term is dependent on the political will of EN countries to cooperate and balance the deficit through coordinated planning and operation of both existing and proposed reservoirs.

3.2.9.3 Economic analysis

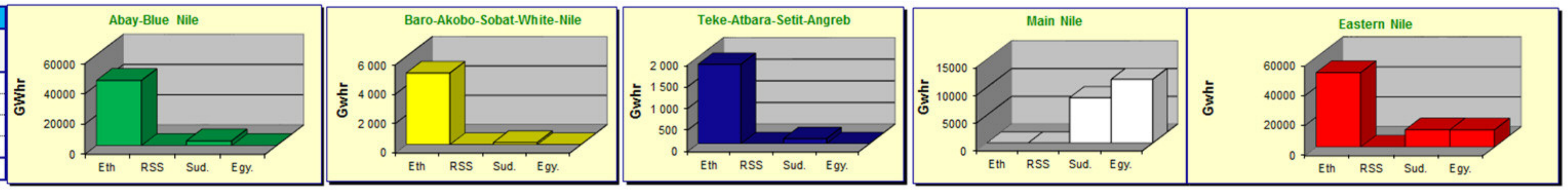
Table 3-17 summarizes the main results of scenario 8 in terms of cost, benefits, social and environmental externalities, employment and food security.

Table 3-17 : Summary of economic results for scenario 8a

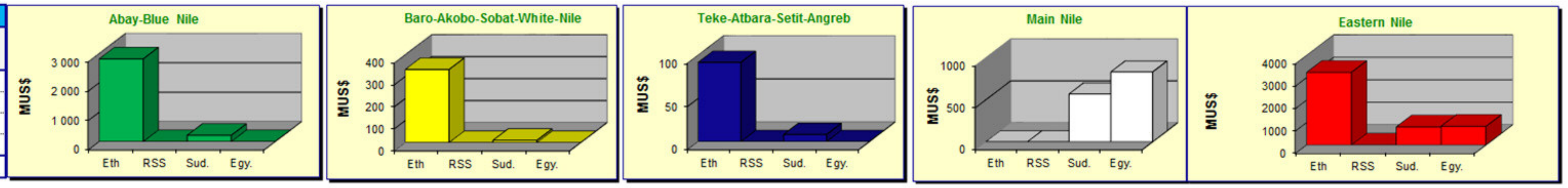
Economic & Social Indicators	**Baseline**	**Scenario 8a**	***Comparison***
Total HP generated (annual average production, in GWh)	**21 721**	72 613	*234%*
Total irrigation area (in 1000 ha)	**6 744**	7 839	*16%*
Water storage requirements (in BCM)	**209**	395	*89%*
Total Revenue Generated (in Million US$)	**4946**	9304	*88%*
			Sector Share
Hydrpower	*1652*	***4872***	***52%***
Irrigated Agriculture	*2254*	***3381***	***36%***
Livestock Associated with Irrigation	*990*	***990***	***11%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***60***	***1%***
Total Employment Generated (in Million Jobs)	**101**	111,3	*10,5%*
			Sector Share
Irrigated Agriculture	*99*	***110***	***98,60%***
Livestock Associated with Irrigation	*2*	***1***	***1,33%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**36 097**	
Net Present Value NPV: (in Million US$)		**61 677**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
20,90	4,01		

Figure 3-9: Summary of economic results for Scenario 8a: Improved situation (IS) + Large Hydropower potential + Moderate Irrigation expansion

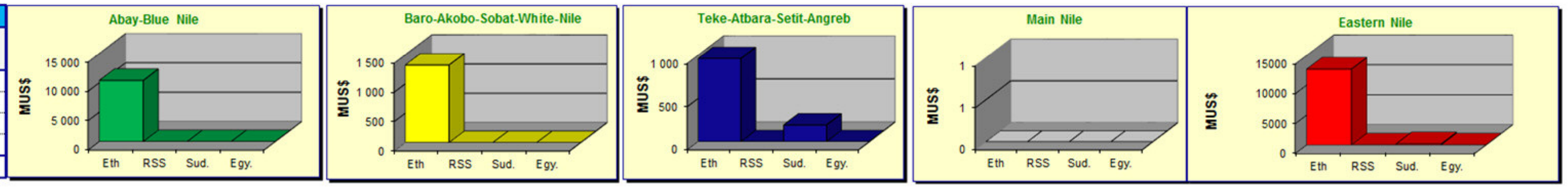
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	42 974	0	3 066	0	**46 040**
BAS-White Nile	4 874	0	143	0	**5 017**
Tekeze-Atbara	1 834	0	118	0	**1 952**
Main Nile	0	0	8 147	11 457	**19 604**
EN-Total	**49 682**	**0**	**11 474**	**11 457**	**72 613**



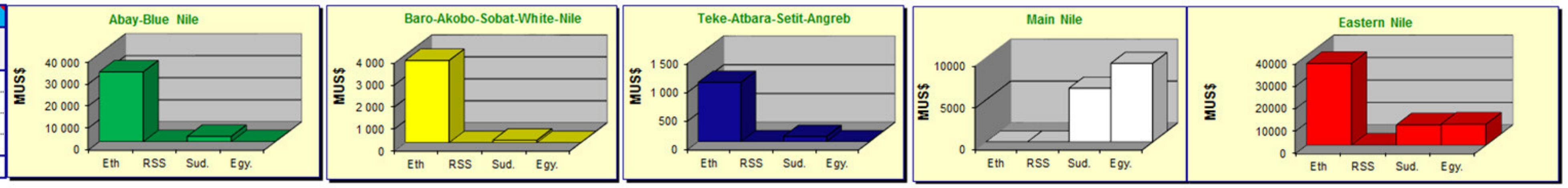
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2 812	0	215	0	**3 027**
BAS-White Nile	332	0	10	0	**342**
Tekeze-Atbara	92	0	8	0	**100**
Main Nile	0	0	570	833	**1 403**
EN-Total	**3 236**	**0**	**803**	**833**	**4 872**



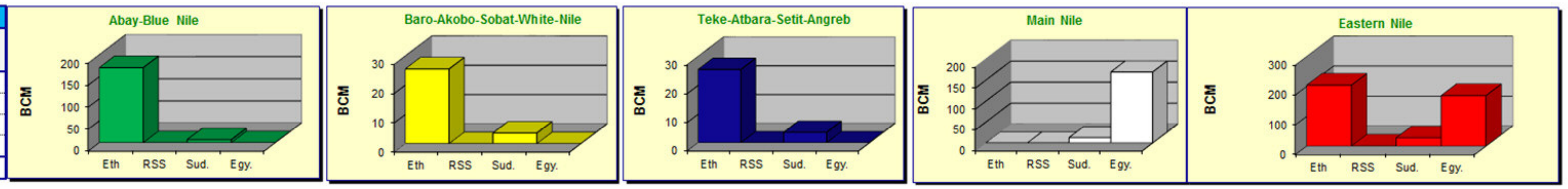
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	10 389	0	0	0	**10 389**
BAS-White Nile	1 322	0	0	0	**1 322**
Tekeze-Atbara	964	0	193	0	**1 157**
Main Nile	0	0	0	0	**0**
EN-Total	**12 675**	**0**	**193**	**0**	**12 868**



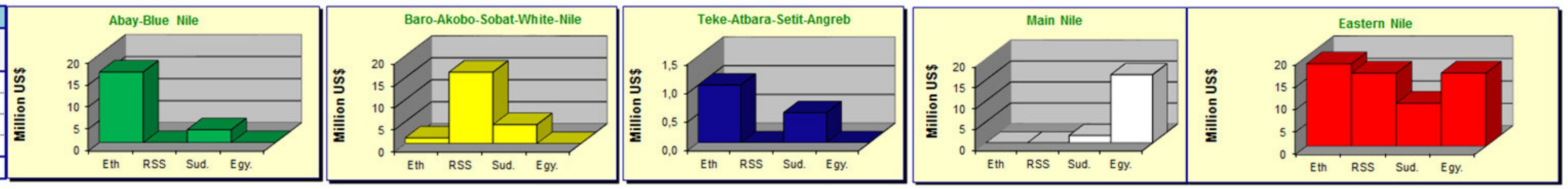
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	31 662	0	2 416	0	**34 078**
BAS-White Nile	3 738	0	113	0	**3 851**
Tekeze-Atbara	1 032	0	93	0	**1 125**
Main Nile	0	0	6 420	9 373	**15 793**
EN-Total	**36 433**	**0**	**9 042**	**9 373**	**54 847**



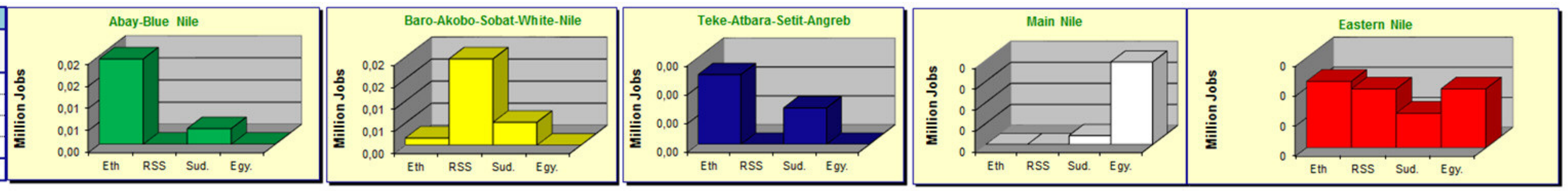
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	170	0	7	0	**177**
BAS-White Nile	8	0	5	0	**6**
Tekeze-Atbara	26	0	4	0	**29**
Main Nile	0	0	13	169	**182**
EN-Total	**204**	**0**	**28**	**169**	**395**



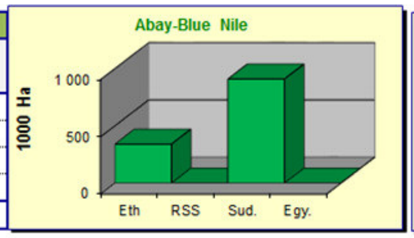
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	16	0	3	0	**19**
BAS-White Nile	1	16	4	0	**22**
Tekeze-Atbara	1	0	1	0	**2**
Main Nile	0	0	2	16	**18**
EN-Total	**18**	**16**	**10**	**16**	**60**

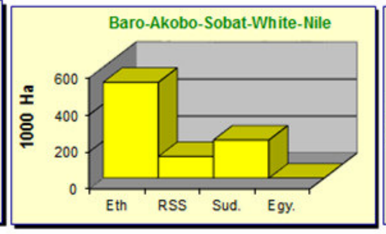


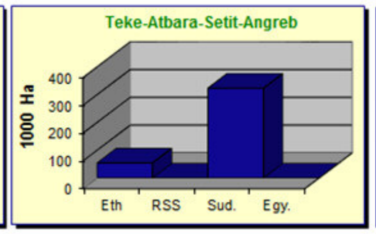
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	**0,02**
BAS-White Nile	0,00	0,02	0,01	0,00	**0,03**
Tekeze-Atbara	0,00	0,00	0,00	0,00	**0,00**
Main Nile	0,00	0,00	0,00	0,02	**0,02**
EN-Total	**0,02**	**0,02**	**0,01**	**0,02**	**0,07**

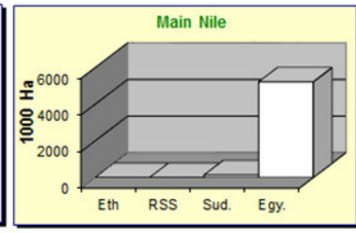


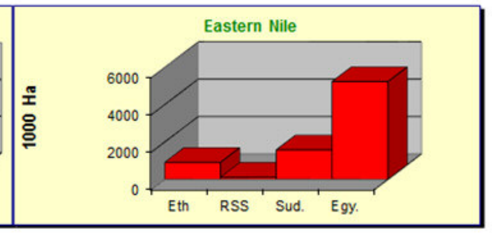
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	341	0	909	0	1 249
BAS-White Nile	518	118	206	0	842
Tekeze-Atbara	55	0	323	0	378
Main Nile	0	0	142	5 228	5 370
EN-Total	913	118	1 580	5 228	7 839



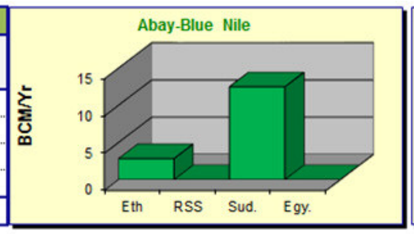


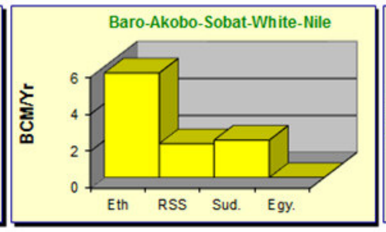


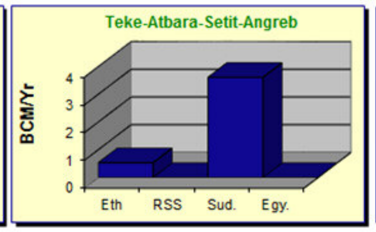


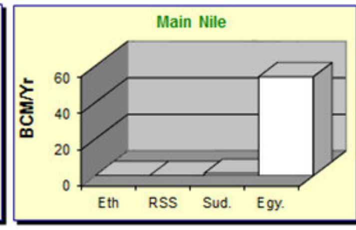


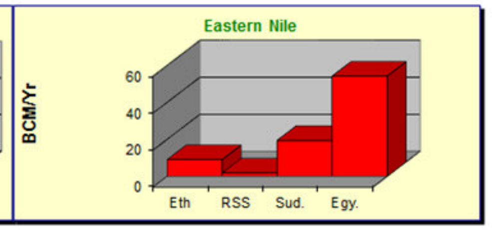
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	3	0	12	0	15
BAS-White Nile	6	2	2	0	10
Tekeze-Atbara	1	0	4	0	4
Main Nile	0	0	1	54	55
EN-Total	9	2	19	54	84



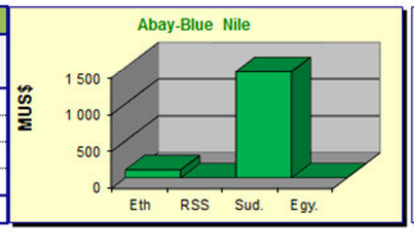


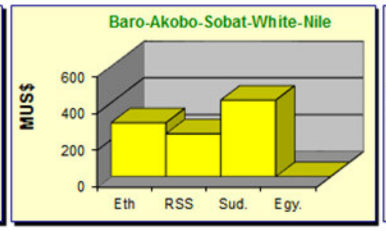


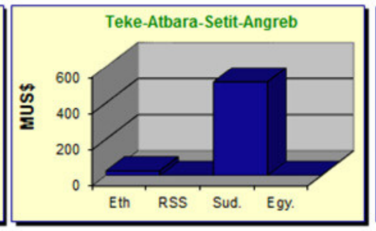


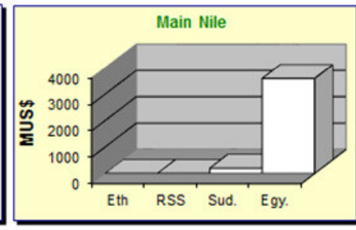


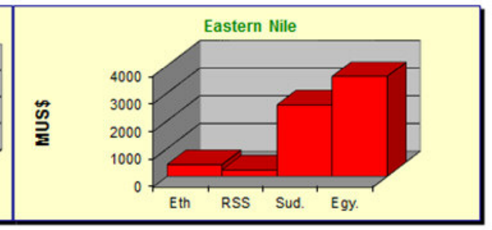
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	109	0	1 442	0	1 551
BAS-White Nile	292	232	414	0	938
Tekeze-Atbara	25	0	516	0	542
Main Nile	0	0	200	3 598	3 798
EN-Total	426	232	2 573	3 598	6 829



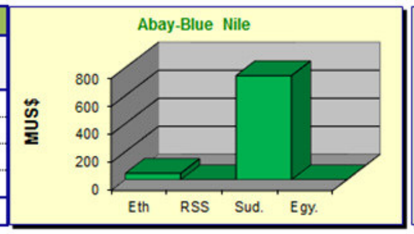


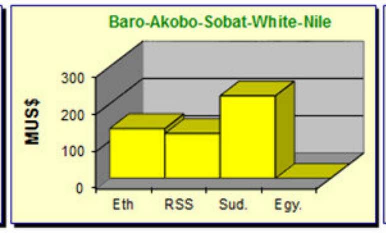


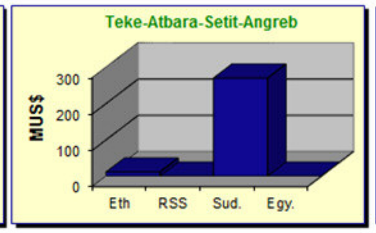


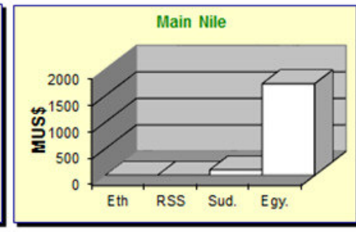


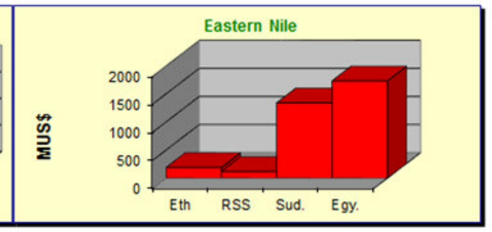
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	46	0	742	0	788
BAS-White Nile	134	120	222	0	476
Tekeze-Atbara	11	0	270	0	282
Main Nile	0	0	105	1 730	1 835
EN-Total	191	120	1 340	1 730	3 381



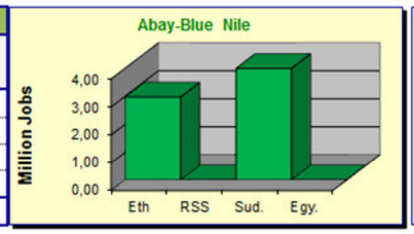


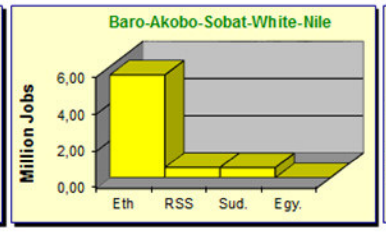


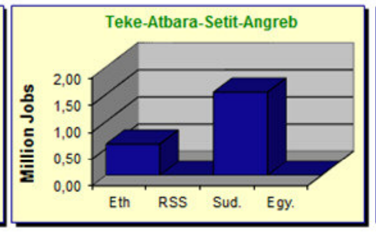


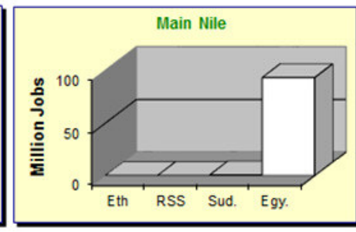


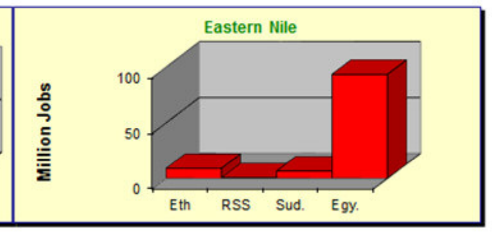
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2,97	0,00	3,99	0,00	7
BAS-White Nile	5,55	0,56	0,55	0,00	7
Tekeze-Atbara	0,58	0,00	1,54	0,00	2
Main Nile	0,00	0,00	0,67	93,36	94
EN-Total	9,11	0,56	6,75	93,36	110



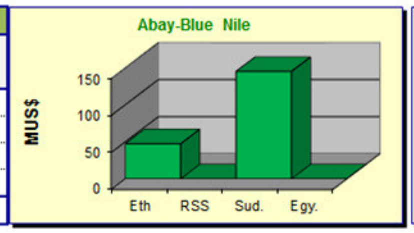


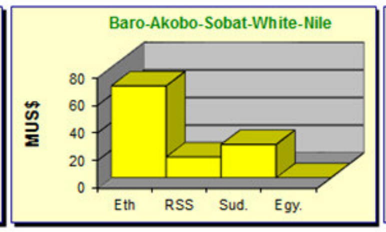


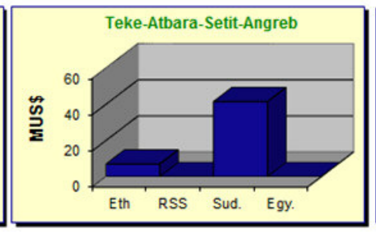


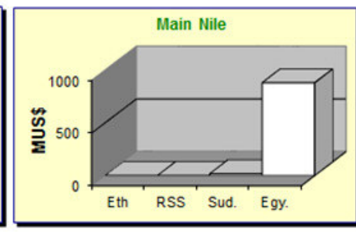


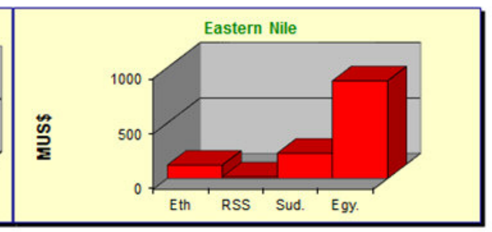
Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	47	0	145	0	192
BAS-White Nile	66	15	24	0	106
Tekeze-Atbara	7	0	42	0	49
Main Nile	0	0	18	881	899
EN-Total	121	15	229	881	1 245



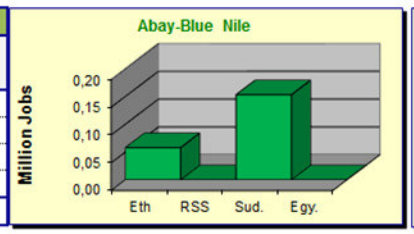


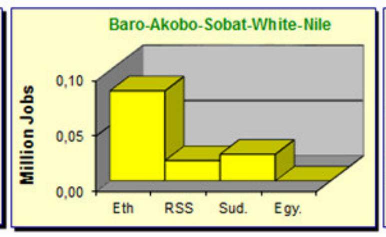


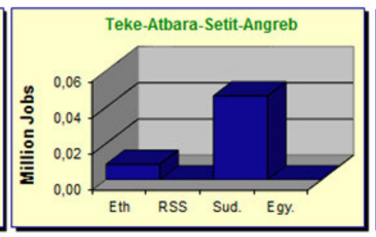


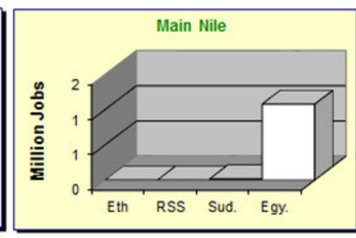


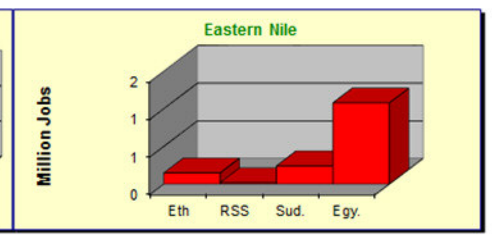
Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,06	0,00	0,15	0,00	0,21
BAS-White Nile	0,08	0,02	0,02	0,00	0,12
Tekeze-Atbara	0,01	0,00	0,05	0,00	0,05
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,15	0,02	0,24	1,08	1,49











3.2.10 Scenario 8b – IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile

3.2.10.1 Introduction

The targeted irrigation Water resources analysis

Scenario 8b address change in cropping patern along main Nile specifically Egypt going going for less consumptive water use crops and improvement in irrigation water demand by 7.5%. This change appears in the table below were Drainage to Mediterranean Sea shows a deficit around 0.7 BCM/yr while it was about 3.3 BCM/ yr in the scenario 8a. (question to Yosif in which he said that there should not be changes, mail 06/03/2015)

Table 3-18 shows the water budget as the results of implementing scenario 8b.

Table 3-18: Summary of water resources results for scenario 8b.

Water Budget	**Baseline**	**Scenario 8b**	***Comparison***
Total Water Uses (in BCM/yr)	**87**	**108**	***24%***
	Per major economic sector		***Share***
Irrigation+Domestic+Livestocks	*67*	*84*	*78%*
Hydropower & Evaporation losses	*20*	*23*	*22%*
		Per countryr	***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*68*	*63%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*14*	*13%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*25*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,1
Blue Nile at Deim	49,7	49,4	46,0
Blue Nile at Khartoum	53,7	44,6	35,0
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	23,3
White Nile at Mogren	28,7	25,7	19,2
Main Nile at Hassanab	82,4	69,7	53,5
Atbara Kilo -3	14,3	11,4	8,3
Main Nile US Aswan	96,7	78,5	61,1
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	-0,7

3.2.10.2 *Economic analysis*

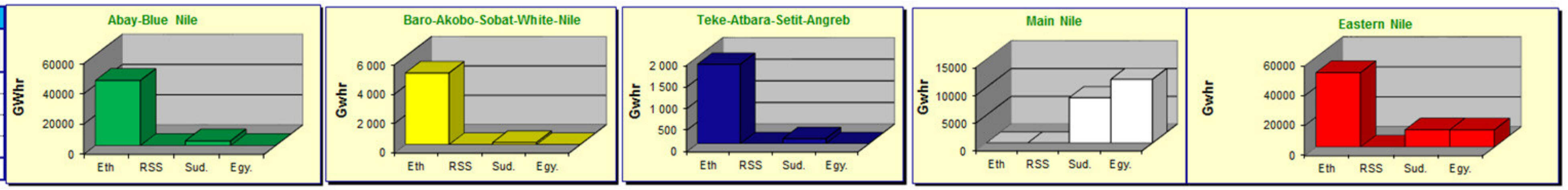
Table 3-19 summarizes the main results of scenario 8b in terms of cost, benefits, social and environmental externalities, employment and food security.

Table 3-19 : Summary of economic results for scenario 8b.

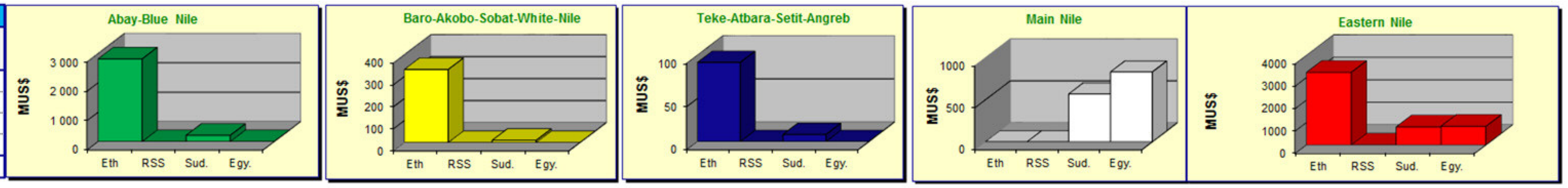
Economic & Social Indicators	Baseline	Scenario 8b	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	72 613	*234%*
Total irrigation area (in 1000 ha)	**6 744**	7 839	*16%*
Water storage requirements (in BCM)	**209**	395	*89%*
Total Revenue Generated (in Million US$)	**4946**	9304	*88%*
Hydrpower	*1652*	***4872***	***52%***
Irrigated Agriculture	*2254*	***3381***	***36%***
Livestock Associated with Irrigation	*990*	***990***	***11%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***60***	***1%***
Total Employment Generated (in Million Jobs)	**101**	111,3	*10,5%*
Irrigated Agriculture	*99*	***110***	***98,60%***
Livestock Associated with Irrigation	*2*	***1***	***1,33%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**36 097**	
Net Present Value NPV: (in Million US$)		**61 677**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
20,90	4,01		

Figure 3-10: Summary of economic results for Scenario 8b: – IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile

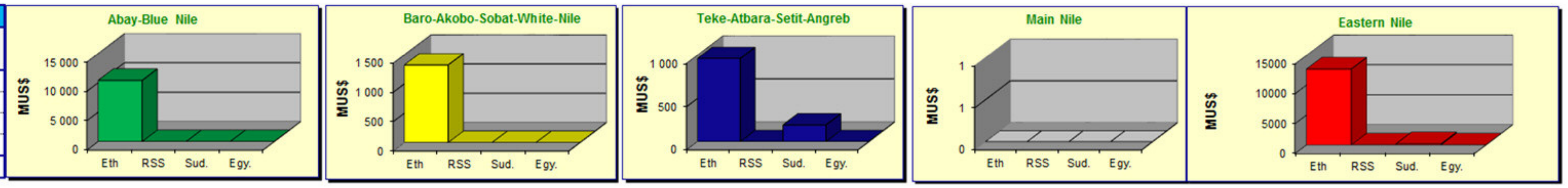
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	42 974	0	3 066	0	46 040
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	8 147	11 457	19 604
EN-Total	49 682	0	11 474	11 457	72 613



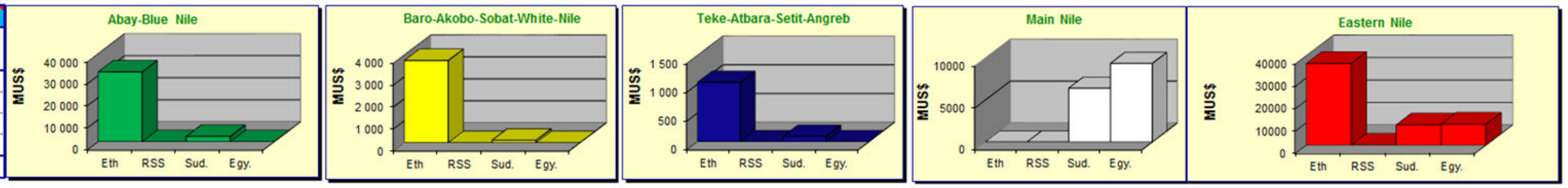
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2 812	0	215	0	3 027
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	570	833	1 403
EN-Total	3 236	0	803	833	4 872



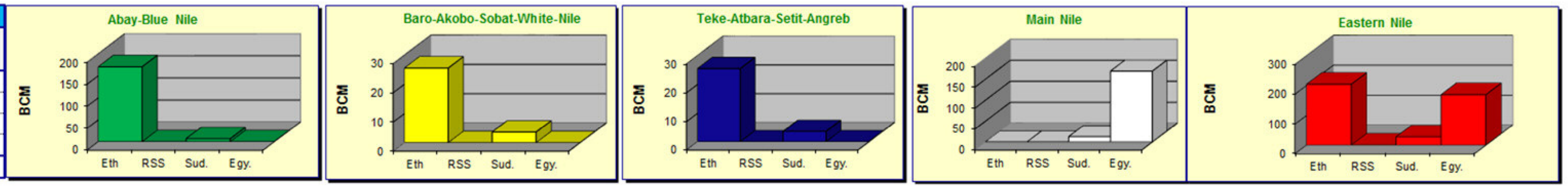
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	10 389	0	0	0	10 389
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	12 675	0	193	0	12 868



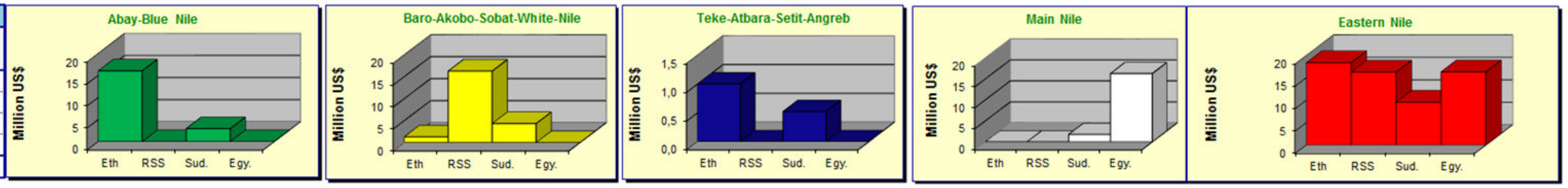
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	31 662	0	2 416	0	34 078
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	6 420	9 373	15 793
EN-Total	36 433	0	9 042	9 373	54 847



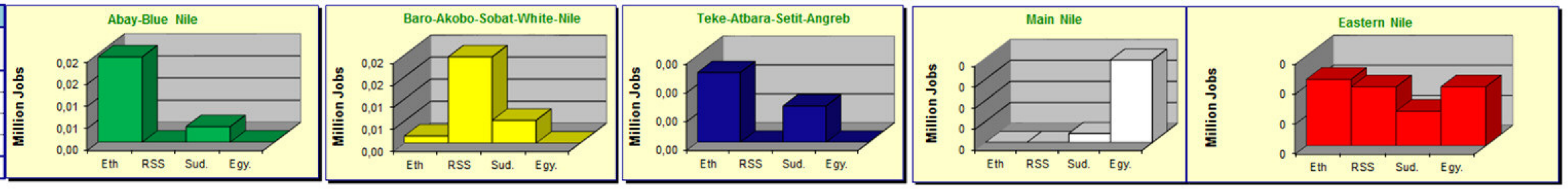
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	170	0	7	0	177
BAS-White Nile	8	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	13	169	182
EN-Total	204	0	28	169	395



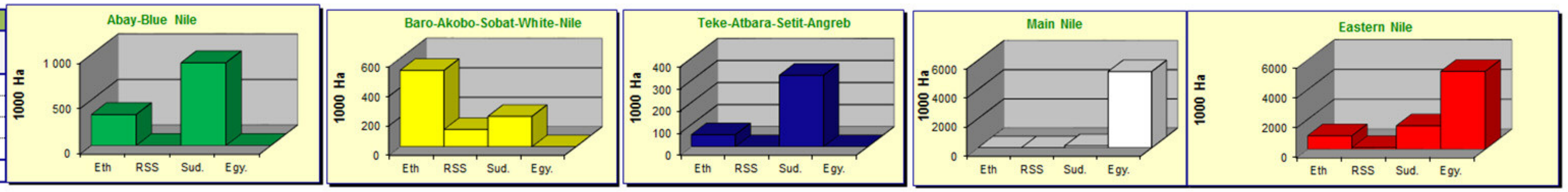
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	16	0	3	0	19
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	18
EN-Total	18	16	10	16	60



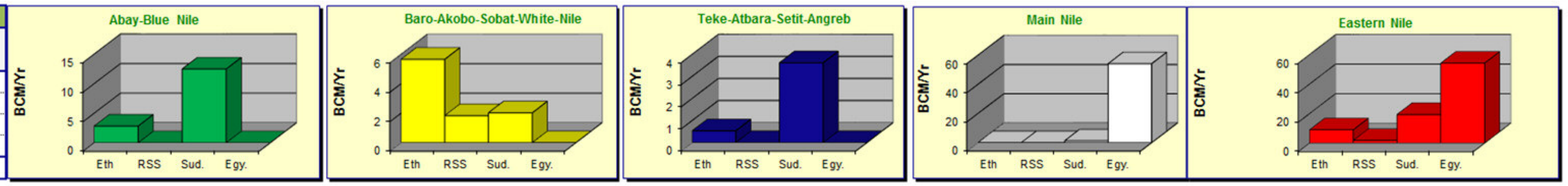
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



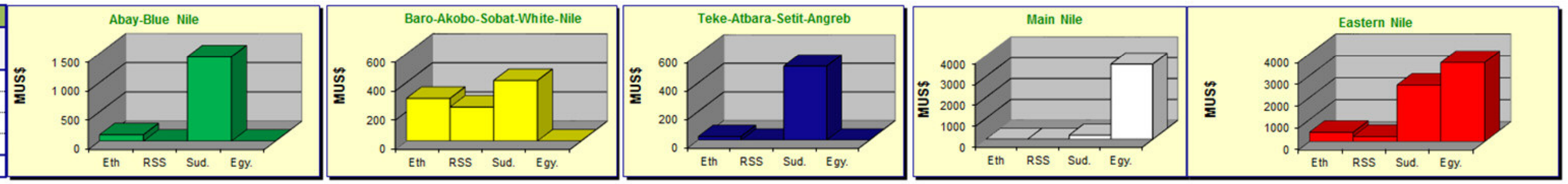
Irrigated Agriculture: Total Irrigated Areas (1000 ha)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	341	0	909	0	1 249
BAS-White Nile	518	118	206	0	842
Tekeze-Atbara	55	0	323	0	378
Main Nile	0	0	142	5 228	5 370
EN-Total	913	118	1 580	5 228	7 839



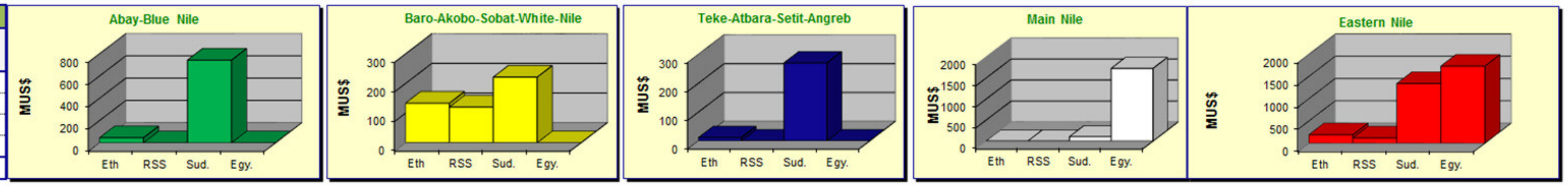
Irrigated Agriculture: Total Water Uses (BCM/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	3	0	12	0	15
BAS-White Nile	6	2	2	0	10
Tekeze-Atbara	1	0	4	0	4
Main Nile	0	0	1	54	55
EN-Total	9	2	19	54	84



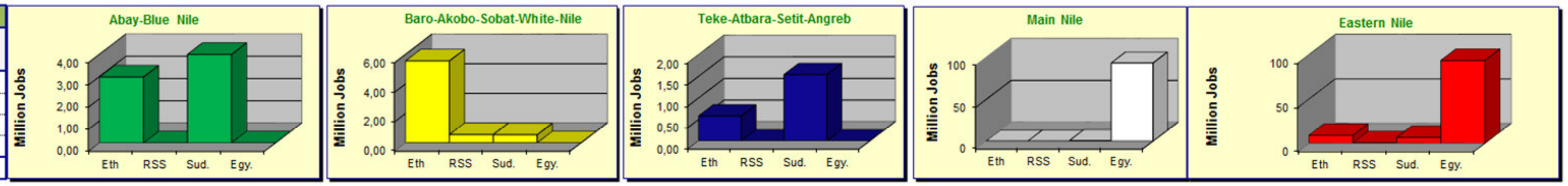
Irrigated Agriculture: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	109	0	1 442	0	1 551
BAS-White Nile	292	232	414	0	938
Tekeze-Atbara	25	0	516	0	542
Main Nile	0	0	200	3 598	3 798
EN-Total	426	232	2 573	3 598	6 829



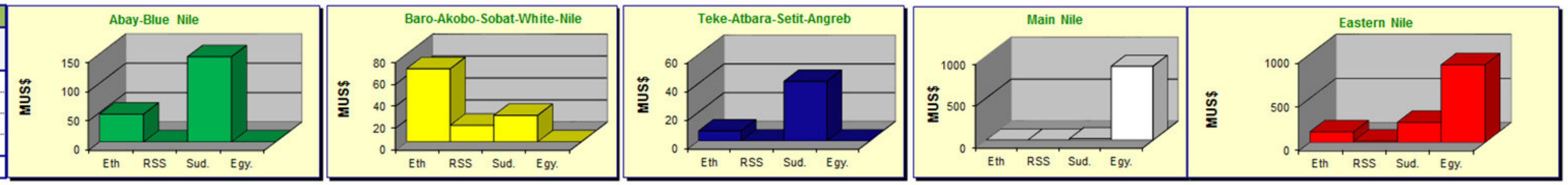
Irrigated Agriculture: Net Revenue Gen. (MUS$ /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	46	0	742	0	788
BAS-White Nile	134	120	222	0	476
Tekeze-Atbara	11	0	270	0	282
Main Nile	0	0	105	1 730	1 835
EN-Total	191	120	1 340	1 730	3 381



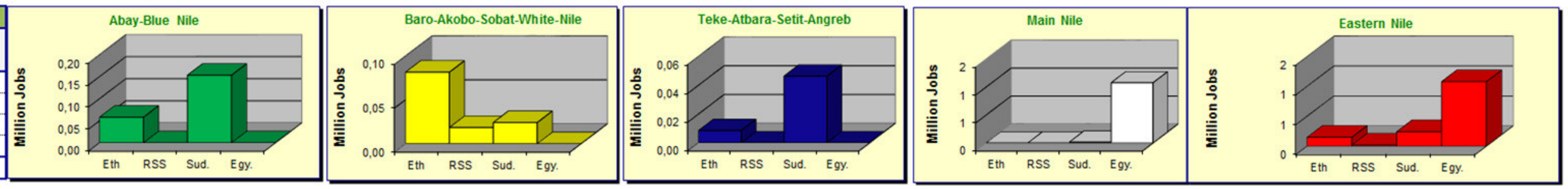
Irrigated Agriculture: Total Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2,97	0,00	3,99	0,00	7
BAS-White Nile	5,55	0,56	0,55	0,00	7
Tekeze-Atbara	0,58	0,00	1,54	0,00	2
Main Nile	0,00	0,00	0,67	93,36	94
EN-Total	9,11	0,56	6,75	93,36	110



Irrigated Agriculture:Livestock Gross Revenue Gen. (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	47	0	145	0	192
BAS-White Nile	66	15	24	0	106
Tekeze-Atbara	7	0	42	0	49
Main Nile	0	0	18	881	899
EN-Total	121	15	229	881	1 245



Irrigated Agriculture: Livestock Employment Gen. (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,06	0,00	0,15	0,00	0,21
BAS-White Nile	0,08	0,02	0,02	0,00	0,12
Tekeze-Atbara	0,01	0,00	0,05	0,00	0,05
Main Nile	0,00	0,00	0,02	1,08	1,10
EN-Total	0,15	0,02	0,24	1,08	1,49



3.2.11 **Scenario 8c – IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile + HAD reduced operating level**

3.2.11.1 Introduction

This scenario is only different from Scenario 8b only in that assumes a much reduced operation level in the HAD.

Table 3-20 shows the water budget as the results of implementing scenario 8b.

Table 3-20: Summary of water resources results for scenario 8c.

Water Budget	**Baseline**	**Scenario 8c**	***Comparison***
Total Water Uses (in BCM/yr)	**87**	**108**	***24%***
	Per major economic sector		***Share***
Irrigation+Domestic+Livestocks	*67*	*84*	*78%*
Hydropower & Evaporation losses	*20*	*23*	*22%*
		Per countryr	***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*68*	*63%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*14*	*13%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*25*	*23%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	49,2
Blue Nile at Khartoum	53,7	44,6	41,1
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	23,3
White Nile at Mogren	28,7	25,7	19,2
Main Nile at Hassanab	82,4	69,7	53,5
Atbara Kilo -3	14,3	11,4	8,3
Main Nile US Aswan	96,7	78,5	61,1
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	0,3

3.2.11.2 Economic analysis

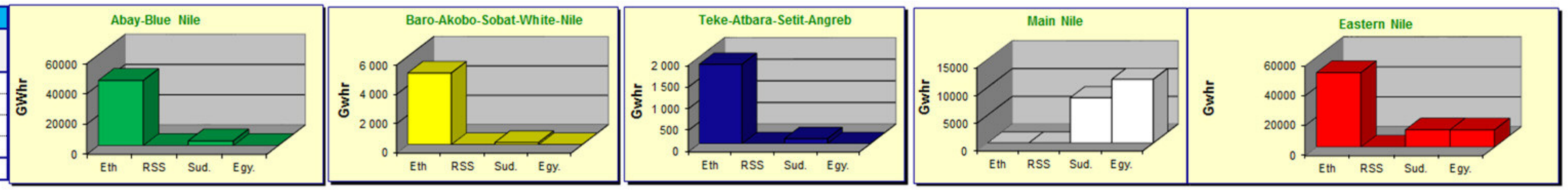
Table 3-21 summarizes the main results of scenario 8b in terms of cost, benefits, social and environmental externalities, employment and food security.

Table 3-21 : Summary of economic results for scenario 8b.

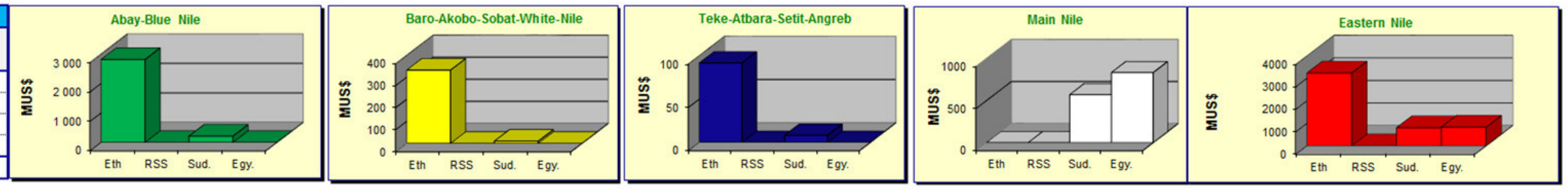
Economic & Social Indicators	Baseline	Scenario 8c	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	72 613	*234%*
Total irrigation area (in 1000 ha)	**6 744**	7 839	*16%*
Water storage requirements (in BCM)	**209**	395	*89%*
Total Revenue Generated (in Million US$)	**4946**	9304	*88%*
			Sector Share
Hydrpower	*1652*	***4872***	***52%***
Irrigated Agriculture	*2254*	***3381***	***36%***
Livestock Associated with Irrigation	*990*	***990***	***11%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***60***	***1%***
Total Employment Generated (in Million Jobs)	**101**	111,3	*10,5%*
			Sector Share
Irrigated Agriculture	*99*	***110***	***98,60%***
Livestock Associated with Irrigation	*2*	***1***	***1,33%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,07%***
Total Investment Cost (in Million US$)		**36 097**	
Net Present Value NPV: (in Million US$)		**61 677**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
20,90	4,01		

Figure 3-11: Summary of economic results for Scenario 8c: IS + Large Hydro+ Moderate Irrig + cropping pattern changes on Main Nile + HAD reduced operating level

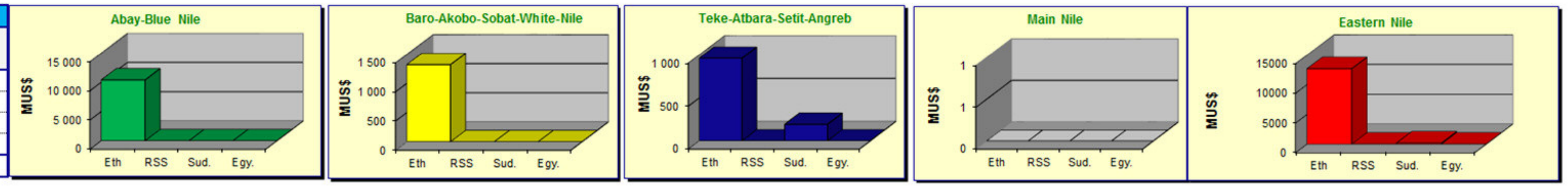
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	42 974	0	3 066	0	46 040
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	8 147	11 457	19 604
EN-Total	49 682	0	11 474	11 457	72 613



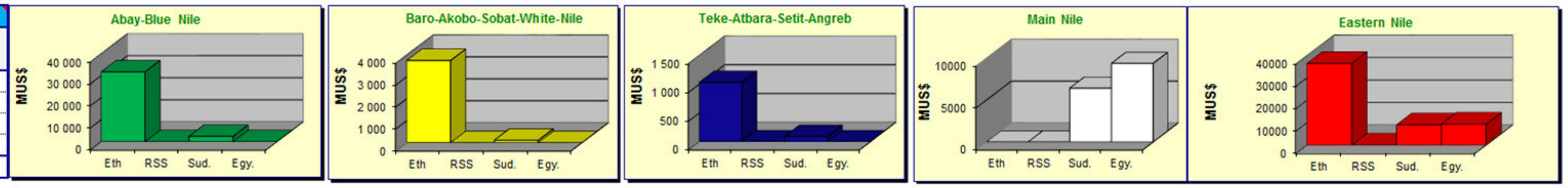
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2 812	0	215	0	3 027
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	570	833	1 403
EN-Total	3 236	0	803	833	4 872



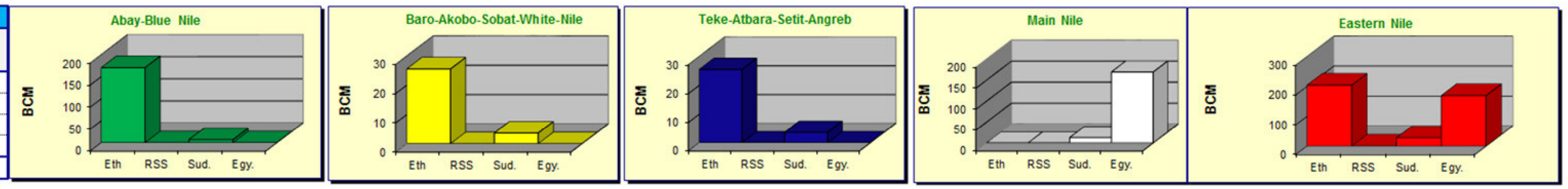
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	10 389	0	0	0	10 389
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	12 675	0	193	0	12 868



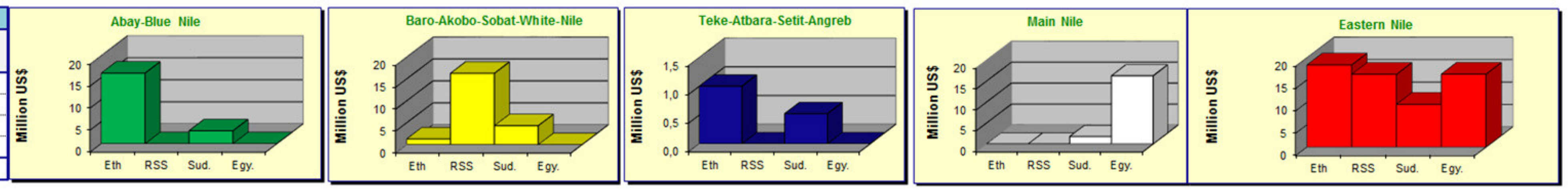
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	31 662	0	2 416	0	34 078
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	6 420	9 373	15 793
EN-Total	36 433	0	9 042	9 373	54 847



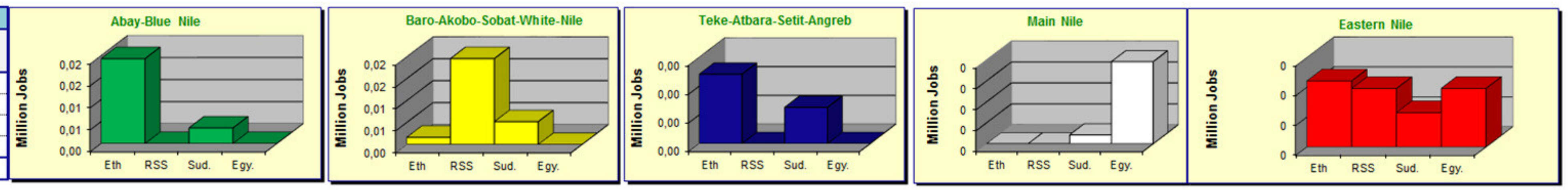
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	170	0	7	0	177
BAS-White Nile	8	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	13	169	182
EN-Total	204	0	28	169	395



Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	16	0	3	0	19
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	18
EN-Total	18	16	10	16	60



Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07



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Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
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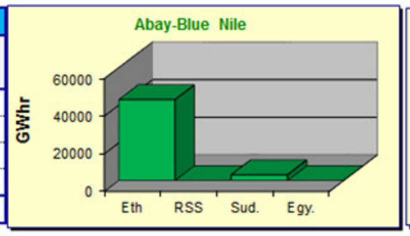
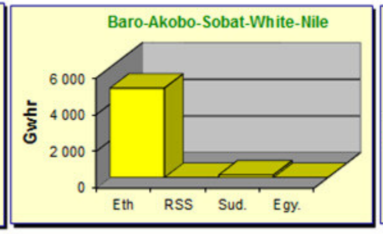
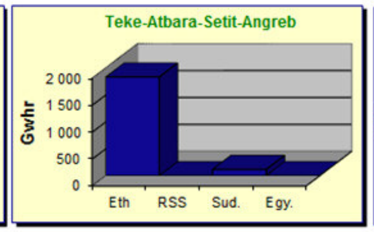
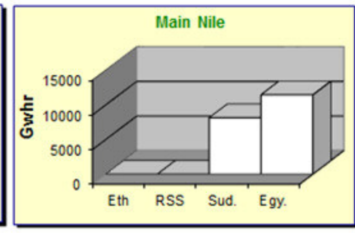
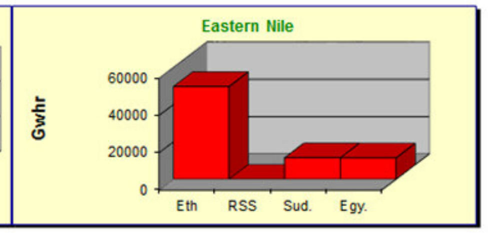
Main Nile	0	0	8 147	11 457	19 604
EN-Total	49 682	0	11 474	11 457	72 613











Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	2 812	0	215	0	3 027
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Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	570	833	1 403
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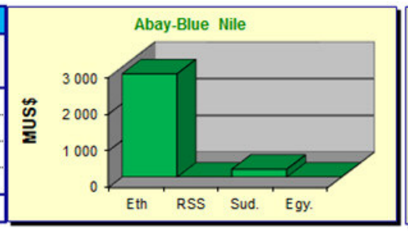

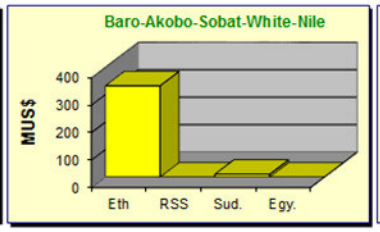

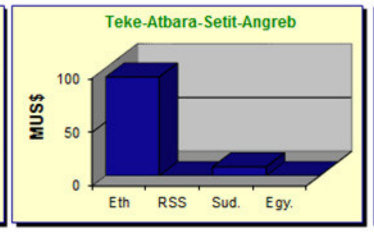

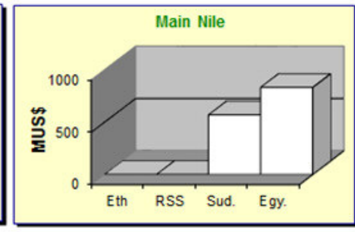

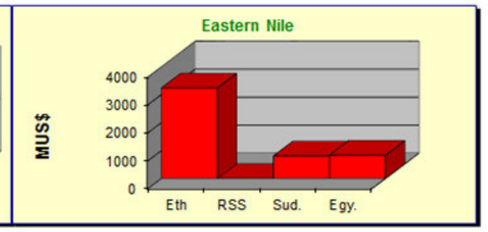

Hydropower: Total Investment Cost (MUS$)					
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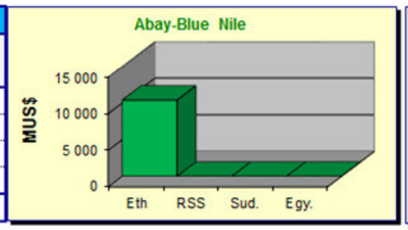
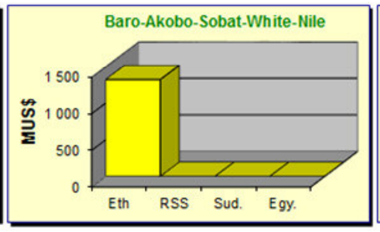
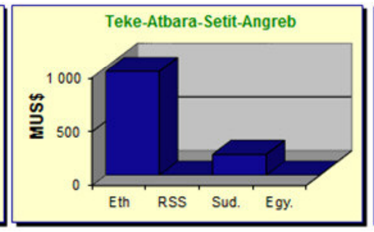
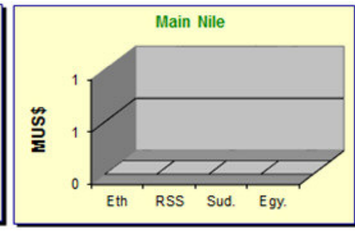
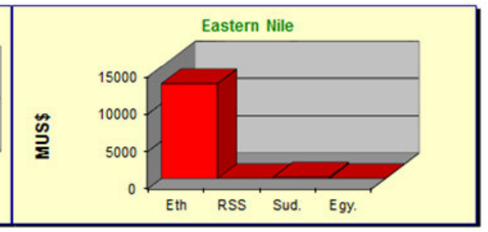
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	12 675	0	193	0	12 868



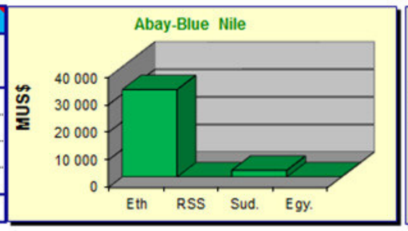


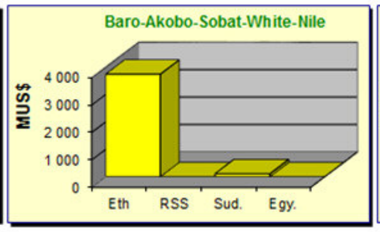


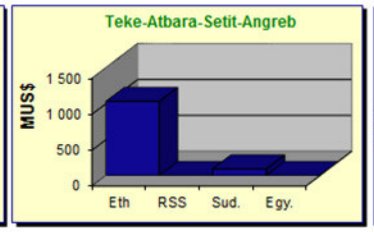


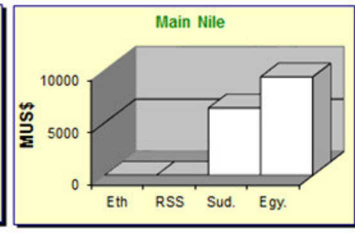


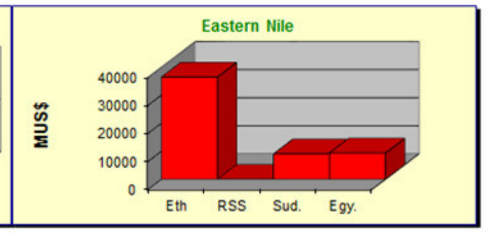
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	31 662	0	2 416	0	34 078
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	6 420	9 373	15 793
EN-Total	36 433	0	9 042	9 373	54 847



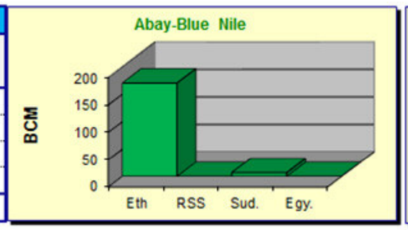


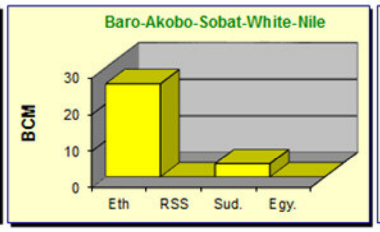


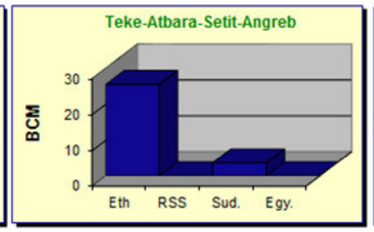


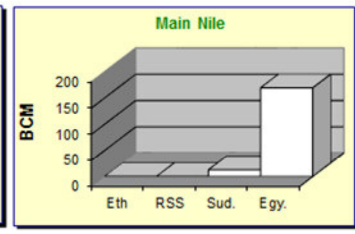


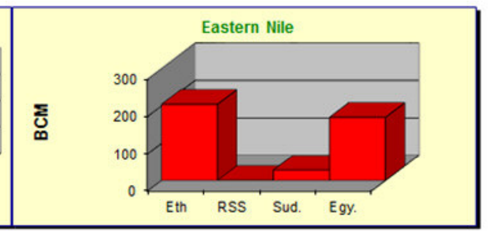
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	170	0	7	0	177
BAS-White Nile	8	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	13	169	182
EN-Total	204	0	28	169	395



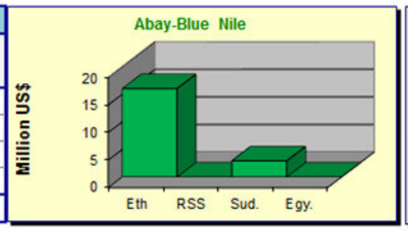


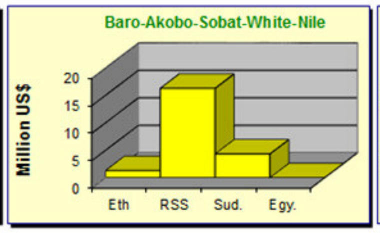


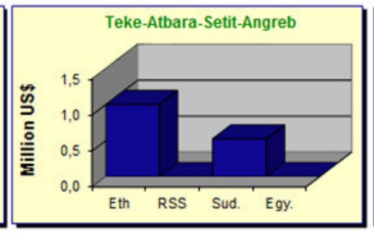


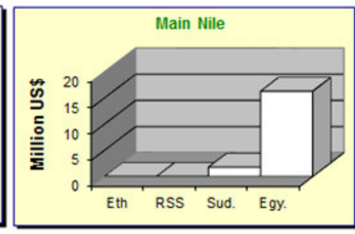


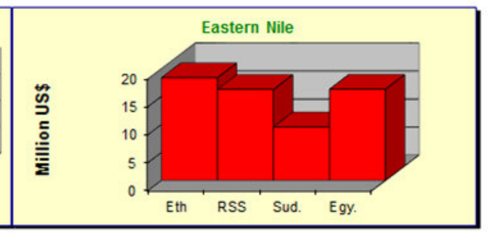
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	16	0	3	0	19
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	18
EN-Total	18	16	10	16	60



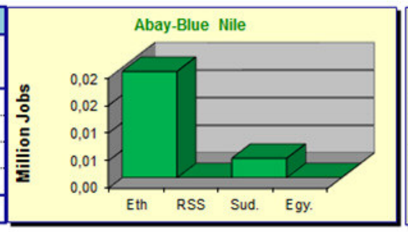


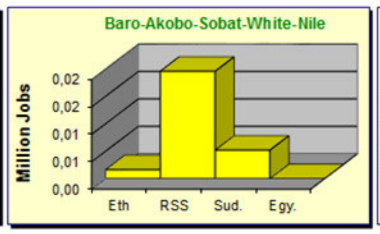


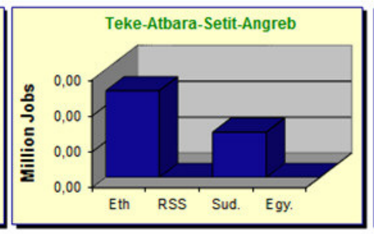


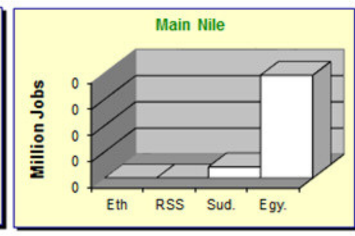


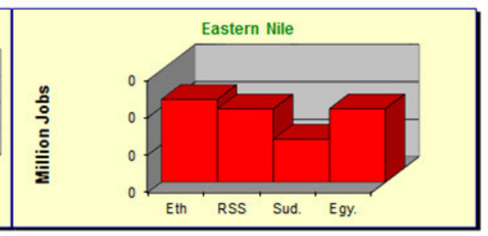
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07











3.2.12 Scenario 9 – IS + Large Hydro+ Managed Irrigation Growth

3.2.12.1 Introduction

This scenario represent the case of managed irrigation growth where curtailment in potential horizontal expansion is made in such a way to: (a) meet existing water demands downstream; (b) balance expansion in such a way each country benefit from the package of investments in this scenario (i.e. create a domain of win-win situation under an enabling environment of cooperation where decision makers agreed to embark on strong level of coordination to optimize the benefits from the limited water resources). Water resources analysis

The comparison in the table below shows the important impacts of lhe scenario on water availability.

Table 3-22: Summary of water resources results for Scenario 9

Water Budget	Baseline	Scenario 9	*Comparison*
Total Water Uses (in BCM/yr)	**87**	**103**	***19%***
	Per major economic sector		***Share***
Irrigation+Domestic+Livestocks	*67*	*81*	*78%*
Hydropower & Evaporation losses	*20*	*22*	*22%*
		Per country	***Share***
Egypt Water Uses (Inc. Evap. Lossess)	*66*	*66*	*64%*
Ethiopia Water Uses (Inc. Evap. Lossess)	*3*	*11*	*10%*
S. Sudan Water Uses (Inc. Evap. Lossess)	*0*	*2*	*2%*
Sudan Water Uses (Inc. Evap. Lossess)	*18*	*25*	*24%*
Average Annual Flows (BCM/yr)			
River Reach	**Natural**	**Baseline**	***Scenario 2***
Abay-Blue Nile at Kessie	16,6	16,5	16,3
Blue Nile at Deim	49,7	49,4	49,2
Blue Nile at Khartoum	53,7	44,6	41,1
Baro at Gambella	12,1	12,1	12,1
White Nile at Melkal	30,1	29,7	25,4
White Nile at Mogren	28,7	25,7	21,3
Main Nile at Hassanab	82,4	69,7	56,4
Atbara Kilo -3	14,3	11,4	8,2
Main Nile US Aswan	96,7	78,5	61,8
Main Nile US Delta	93,0	43,1	43,1
Drainage to Meditteranean Sea	0,0	12,6	-1.05

3.2.12.2 Economic analysis

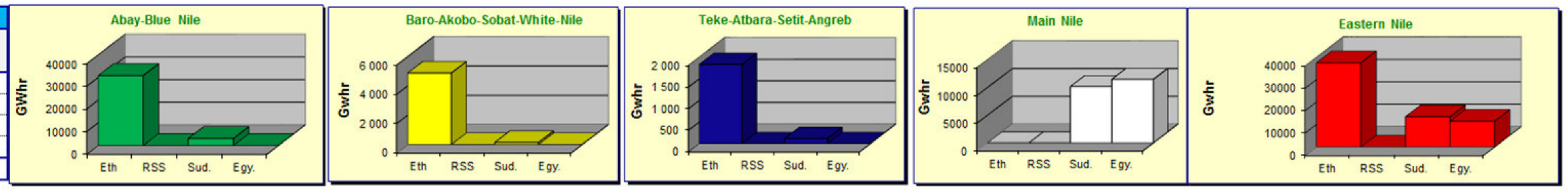
Table 3-23 summarizes the main results of the scenario 9 in terms of cost, benefits, social and environmental externalities, employment and food security.

Table 3-23 : Summary of economic results for Scenario 9.

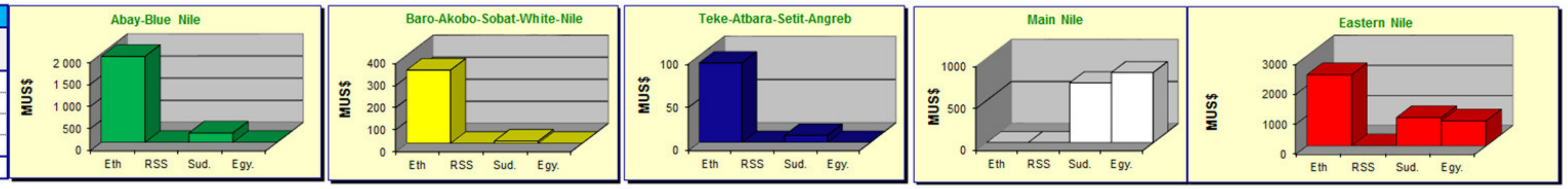
Economic & Social Indicators	Baseline	Scenario 9	*Comparison*
Total HP generated (annual average production, in GWh)	**21 721**	62 494	*188%*
Total irrigation area (in 1000 ha)	**6 744**	7 723	*15%*
Water storage requirements (in BCM)	**209**	349	*67%*
Total Revenue Generated (in Million US$)	**4946**	8580	*73%*
Hydrpower	*1652*	***4142***	***48%***
Irrigated Agriculture	*2254*	***3390***	***40%***
Livestock Associated with Irrigation	*990*	***990***	***12%***
Fisheries (Natural Lakes and Reservoirs)	*50*	***59***	***1%***
Total Employment Generated (in Million Jobs)	**101**	108,8	*8,0%*
Irrigated Agriculture	*99*	***107***	***98,60%***
Livestock Associated with Irrigation	*2*	***1***	***1,33%***
Fisheries (Natural Lakes and Reservoirs)	*0*	***0***	***0,06%***
Total Investment Cost (in Million US$)		**29 513**	
Net Present Value NPV: (in Million US$)		**53 438**	
Net Revenue Generated per Cubic meter			
HP (US Cents/m3)	**Irrigation (US Cents/m3)**		
18,44	4,20		

Figure 3-12: Summary of economic results for Scenario 9: Improved situation (IS) + Large Hydro + Managed Irrigation Growth

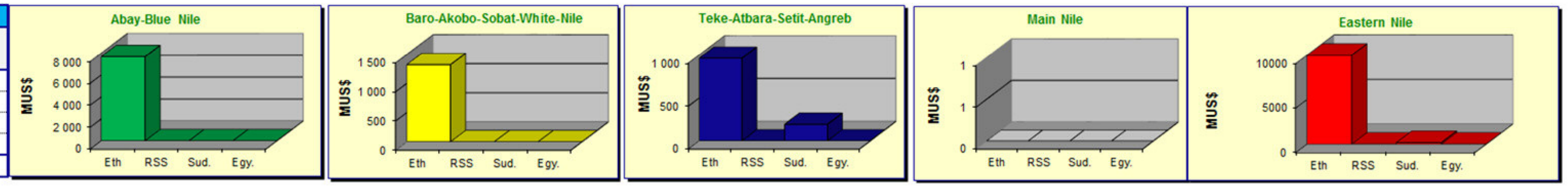
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	30 855	0	3 066	0	33 921
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	10 147	11 457	21 604
EN-Total	37 563	0	13 474	11 457	62 494



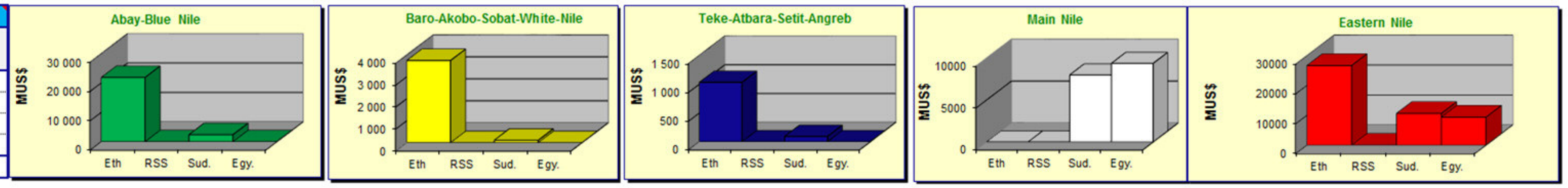
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	1 942	0	215	0	2 157
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	710	833	1 543
EN-Total	2 366	0	943	833	4 142



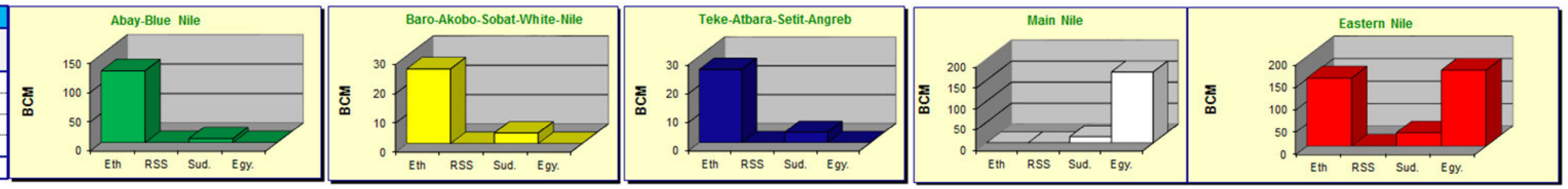
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	7 684	0	0	0	7 684
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	9 970	0	193	0	10 163



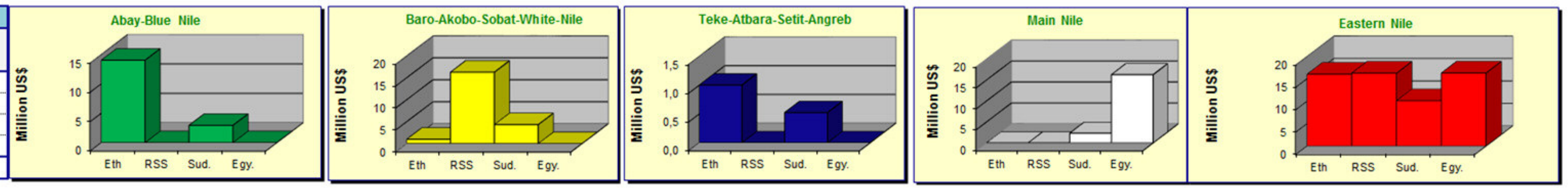
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	21 866	0	2 416	0	24 282
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	7 996	9 373	17 369
EN-Total	26 637	0	10 618	9 373	46 628



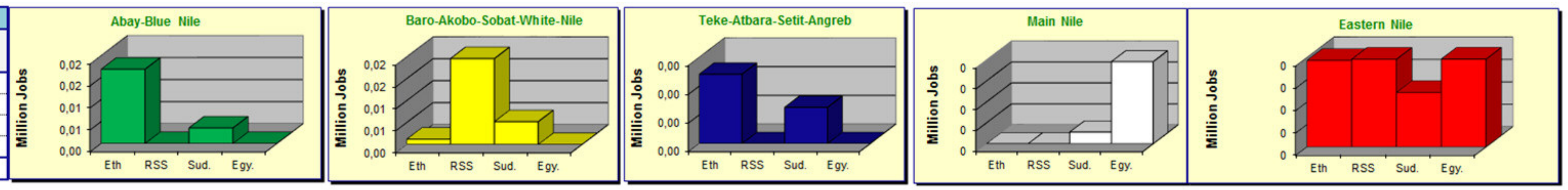
Storage Requirements: (BCM /yr))					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	122	0	7	0	129
BAS-White Nile	4	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	15	169	184
EN-Total	152	0	30	169	349



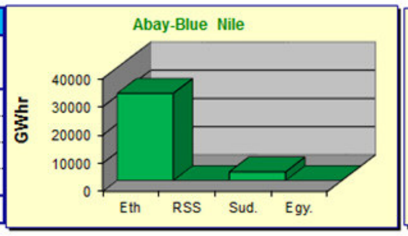
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	14	0	3	0	17
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	19
EN-Total	16	16	10	16	59

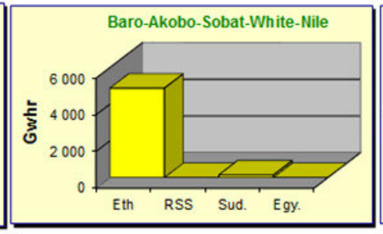


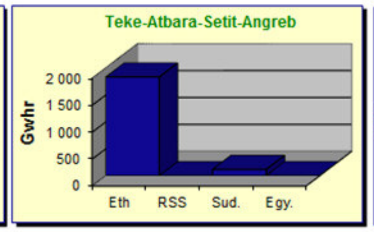
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin	Eth	RSS	Sud.	Egy.	Total
and country	0	0	0	0	0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07

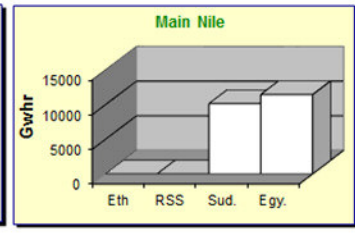


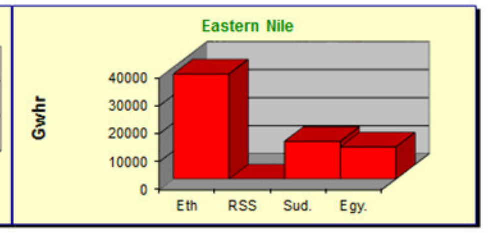
Hydropower : Total Energy Generated (Gwhr /yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	30 855	0	3 066	0	33 921
BAS-White Nile	4 874	0	143	0	5 017
Tekeze-Atbara	1 834	0	118	0	1 952
Main Nile	0	0	10 147	11 457	21 604
EN-Total	37 563	0	13 474	11 457	62 494



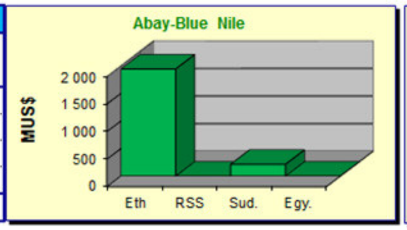


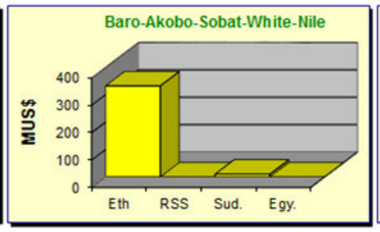


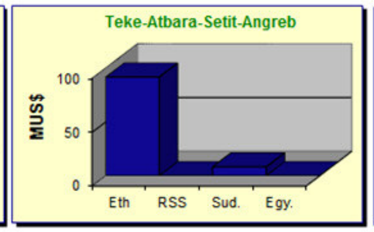


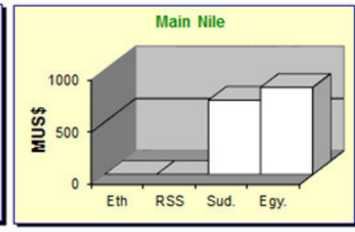


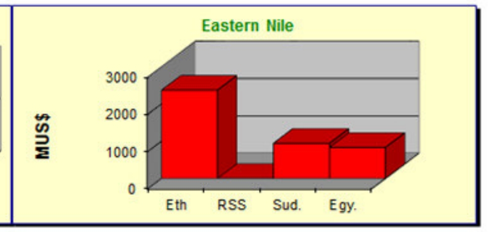
Hydropower: Net Revenue Gen. (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	1 942	0	215	0	2 157
BAS-White Nile	332	0	10	0	342
Tekeze-Atbara	92	0	8	0	100
Main Nile	0	0	710	833	1 543
EN-Total	2 366	0	943	833	4 142



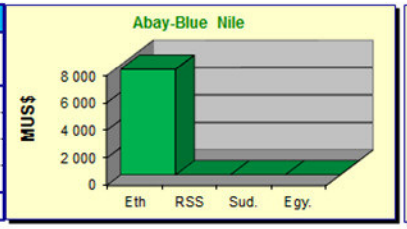


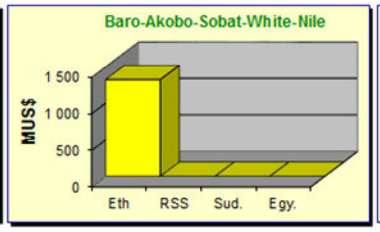


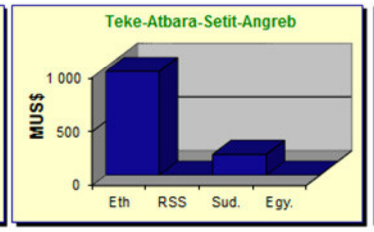


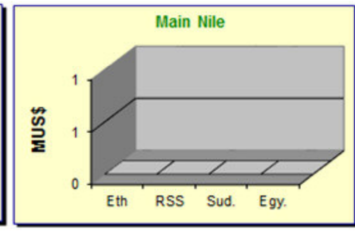


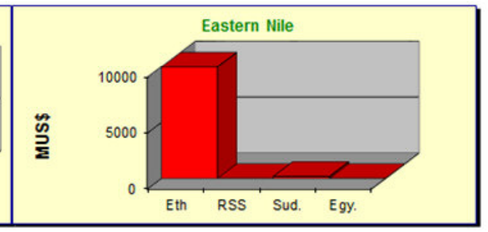
Hydropower: Total Investment Cost (MUS$)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	7 684	0	0	0	7 684
BAS-White Nile	1 322	0	0	0	1 322
Tekeze-Atbara	964	0	193	0	1 157
Main Nile	0	0	0	0	0
EN-Total	9 970	0	193	0	10 163



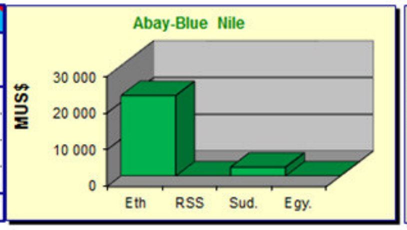


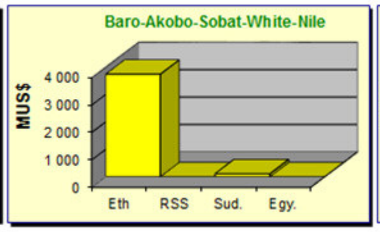


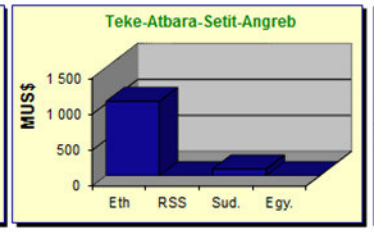


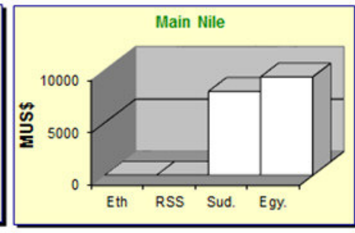


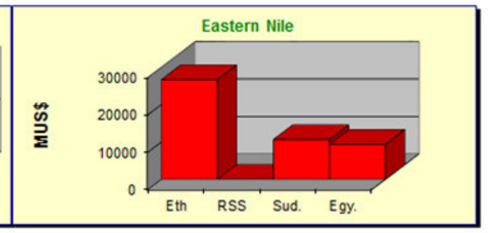
Hydrpower: Net Present Value NPV (MUS$) over 30 years					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	21 866	0	2 416	0	24 282
BAS-White Nile	3 738	0	113	0	3 851
Tekeze-Atbara	1 032	0	93	0	1 125
Main Nile	0	0	7 996	9 373	17 369
EN-Total	26 637	0	10 618	9 373	46 628



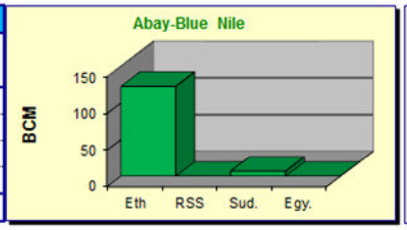


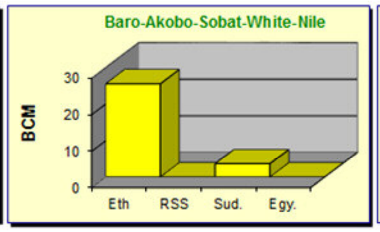


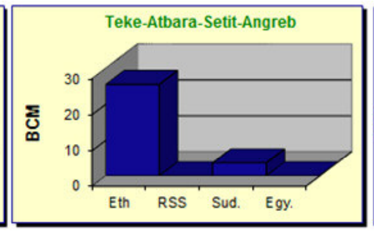


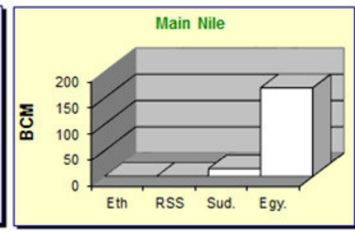


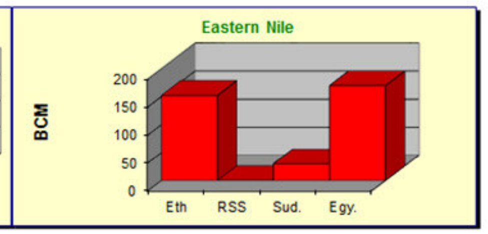
Storage Requirements: (BCM /yr))					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	122	0	7	0	129
BAS-White Nile	4	0	5	0	6
Tekeze-Atbara	26	0	4	0	29
Main Nile	0	0	15	169	184
EN-Total	152	0	30	169	349



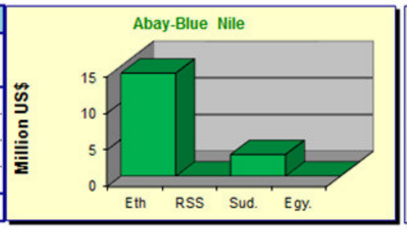


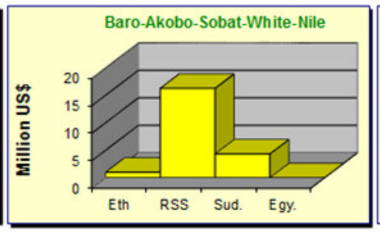


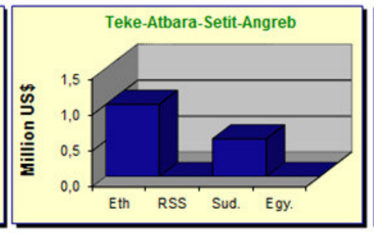


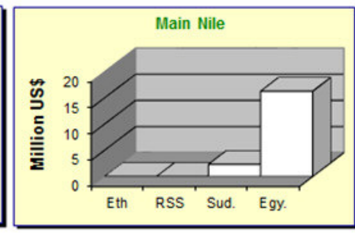


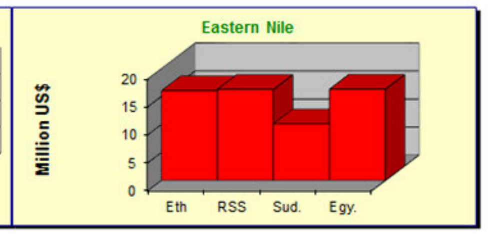
Fisheries (Lakes & Reservoirs): Revenues (MUS$/Yr)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	14	0	3	0	17
BAS-White Nile	1	16	4	0	22
Tekeze-Atbara	1	0	1	0	2
Main Nile	0	0	2	16	19
EN-Total	16	16	10	16	59



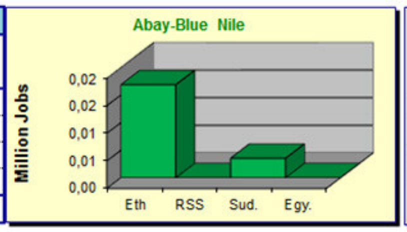


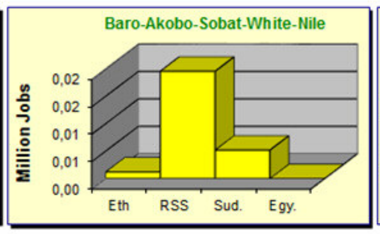


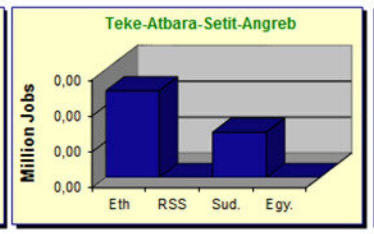


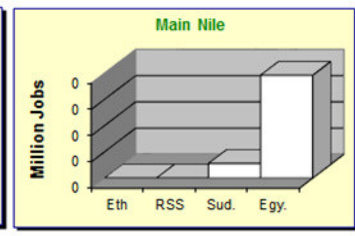


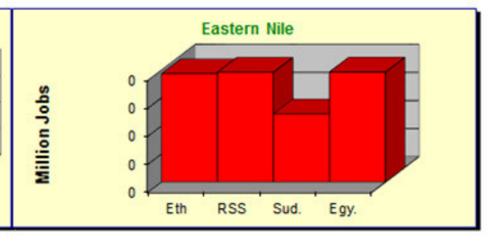
Fisheries (Lakes & Reservoirs): Employment (Millions)					
Break down by sub-basin and country	Eth 0	RSS 0	Sud. 0	Egy. 0	Total 0
Abay-Blue Nile	0,02	0,00	0,00	0,00	0,02
BAS-White Nile	0,00	0,02	0,01	0,00	0,03
Tekeze-Atbara	0,00	0,00	0,00	0,00	0,00
Main Nile	0,00	0,00	0,00	0,02	0,02
EN-Total	0,02	0,02	0,01	0,02	0,07











3.3 Summary of Results of the Scenario Analysis

In the following figures and tables, the results of the different scenarios have been summarised and compared in terms of the key outputs. These ouputs include many of the indictarors required for application of the multi citieria analysis (MCA) (see Section 3.4.2).

Figure 3-13 and Figure 3-14 clearly show the 4 development levels for hydropower and the 4 development levels for irrigation. Some variations of these levels are also observed due to water availability constraints (scenarios 7 &8). These figures are intentionally displayed below each other to allow a clear picture of the hydropower and irrigation combinations inferred.

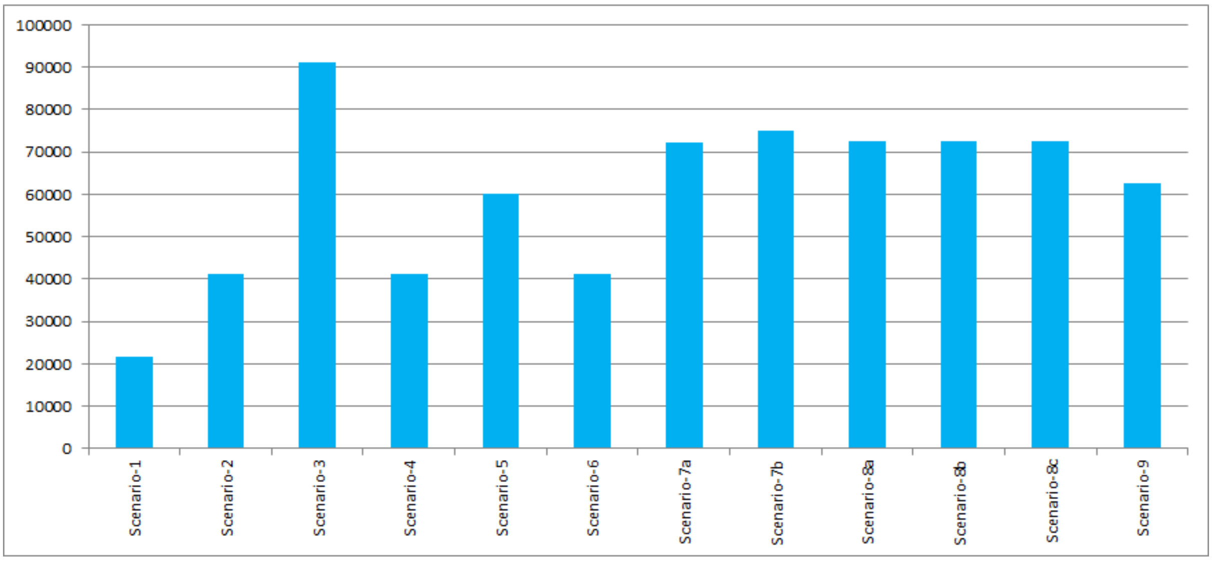


Figure 3-13 : Total hydropower generated (annual average production, in GWh) per scenario

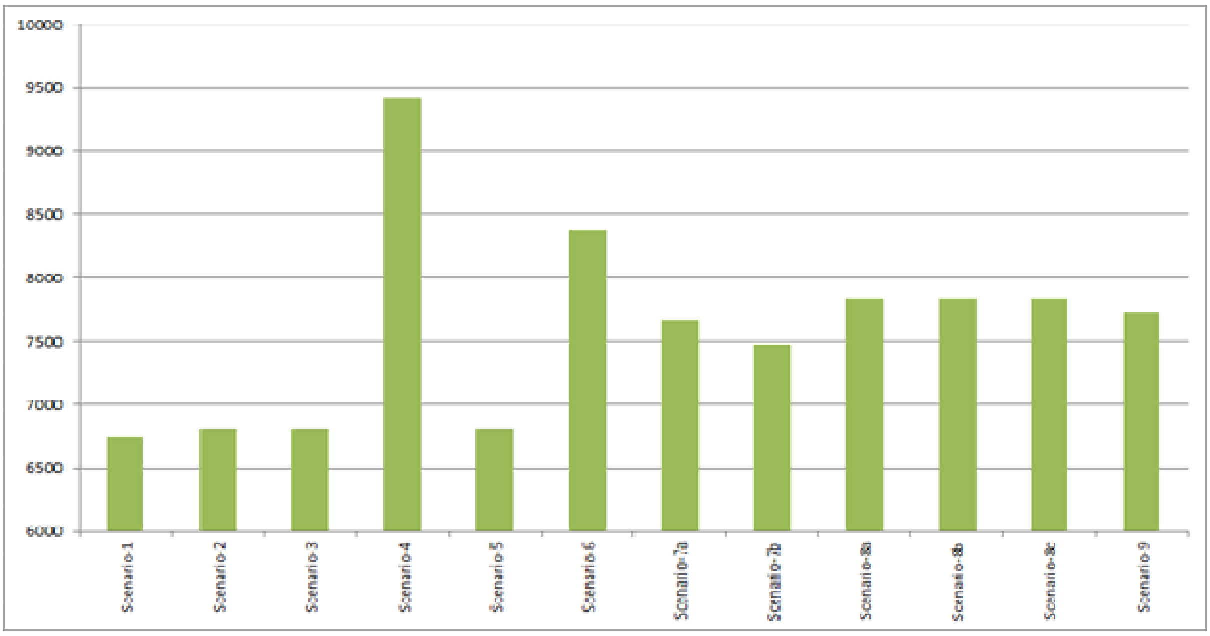


Figure 3-14 : Total irrigated area (in 1000 ha) per scenario

Figure 3-15 below compares again the scenarios in terms of hydropower production and irrigated areas, but also with the net annual revenue generated. The diameter of the circle depends on the returen from the total investments in each scenario. The larger the circle is, the larger the NPV will be.

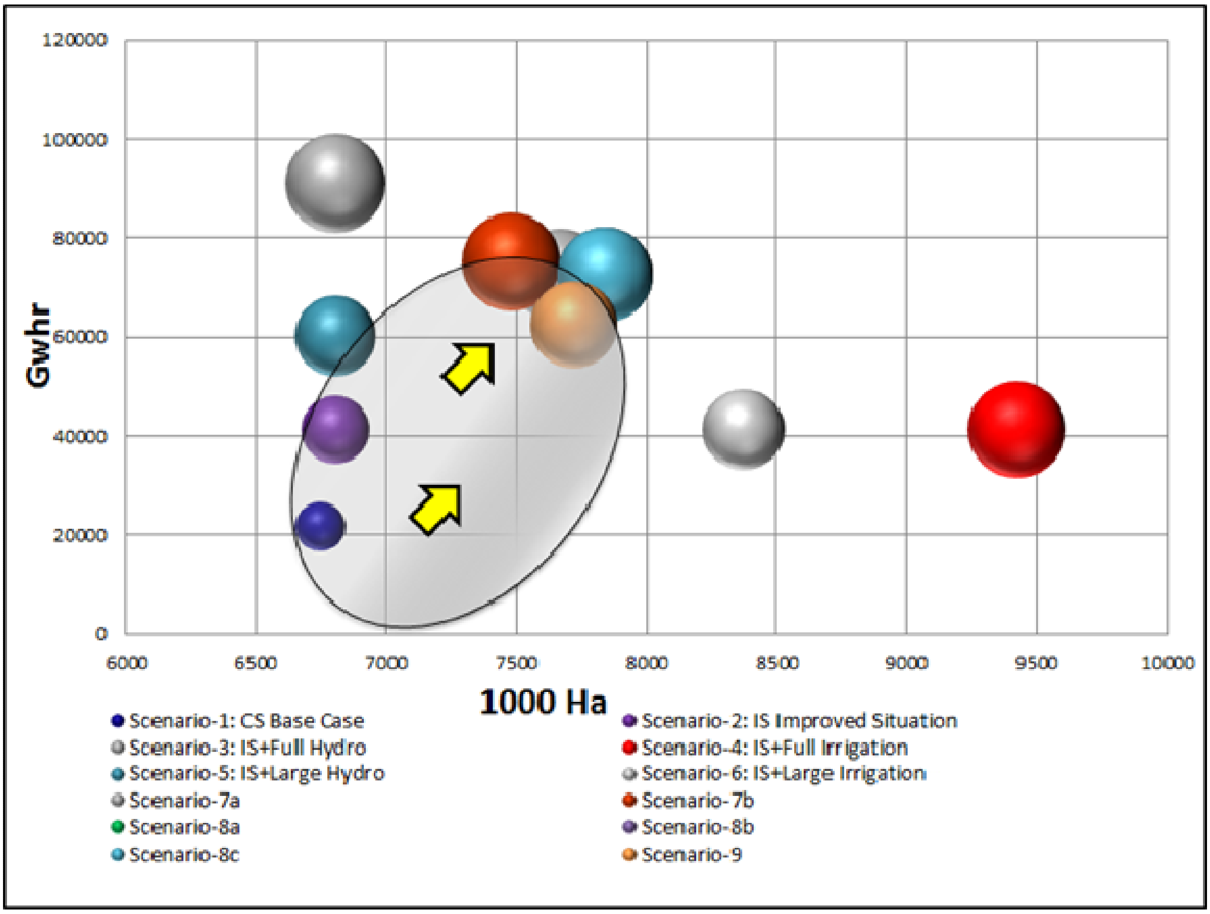


Figure 3-15 : Hydropower production, irrigation and Net Return by scenario

Not surprisingly in view of the fact that investments are being made, both an increase in the total area under irrigation or in hydropower will increases the NPV. However, if the EIRR was compared, only scenarios with increased hydropower show a high EIRR.

The shaded oval provides an envelope of water availability. Scenarios outside this oval ate affected by the **constraint of water availability.**

- The two red circles are the two scenarios of large and full irrigation potential. **Full irrigation development is clearly unfealistic** in terms of water constratints.
- It is interesting to note the steep gradient in moving from CS to scenario 9 which is deemed to be one of the most the viable options. This is mainly attributed to the large return from hydropower. The average water productivity from hydropower generation is estimated to be about 0.21 US$/m³ while the average water productivity for irrigation agriculture is about 0.06 US$/m³ . Hence the gradient along the shortest path from CS to scenario 9 is of the same order.

3.4 MULTI-CRITERIA ANALYSIS OF THE SCENARIOS

3.4.1 Introduction

The scenarios have provided a steo by step movement from the current situation to a envelope of reasonable ultimate development options. Simple analysis of the scenarios, results, therefore, does provide use with some initial, quite clear conlcusions:

- Development of full irrigation potential is not possible without resulting in large water shortages in Egypt
- Development of the large potential of irrigation basinwide is also likely to cause some water shortages downstream. Maximising irrigation potential in the upstream should be investigated along the following axes:
    - Careful investigation of which would be the most productive and efficient on a sub-basin by su b-basin basis
    - Investigation in to the possibility of adopting a regional approach to food security
        - so that the choice of crops …
        - Combination of water efficiency (possible lower application rates in uplands) and cost-effectiveness (lower set up costs and more potential for double-cropping in the lowlands.)
        - Cross-border guarantees for supply of crops, regionally-based pricing systems etc.
- Development of hydropower even at its fully (identified) potential has little impact on the availability of water downstream. However, the omission of less feasible reservoir-based schemes on the Main Nile would seem advisable since these schemes are unlikemy to be cost-effective in ther current forms.

3.4.2 Application of the Multi-criteria Analysis

The results of the scenarios analhysis can provide these startegic orientations but as already indicated in Chapter 2 of this report, it is considered useful use a multicriteria analysis ro analyse the scenario results in a bit more depth and with a degree of objectivity

The multi-criteria anamysis methodology was described in Chapter 2 of this report. However, while collecting the data for each indicator, it was decided to abandon the use of 2 criterias for want of data required to put values to these indiacators. The **MEF-SA** and the **Ter-Ecol** were omitted. Preferences with respect to weighting have been aggregated and resultats expressed as percentages are shown in Table 3-24.

Table 3-24 : Weights of criteria reflectiong stakeholder preferences

Criteria	Total	Weights (%)
NPV	28,00	18%
Empl	11,00	7%
BCM-Eg	21,00	13%
Gini	21,00	13%
WP	29,00	19%
Resetl	17,00	11%
Evap	29,00	19%
	156,00	**100%**

The highest weighting has been given to the system wide performance expressed by the criteria of evaporation. In view of the evident critical issue of water availability, it was agreed by all stakeholders that the minimization of the water losses at the regional level is critical.

Water productivity in the irrigation sector comes next, with the same weight. The result highlights the preference of the countries to take into consideration the comparative advantages of countries to the selection of the scenario.

Next criteria in terms of ranking is the NPV followed by Equity (Gini index), the water balance (BCM-Eg) and the social impacts of HP dams and finaly Employment.

These preference have been used to weight the criteria and the weighted score are shown in .

Table 3-25: Summary of indicators and their values

Label	Criteria / Indicator	SC3	SC5	SC6	SC7a	SC7b	SC8a	SC8b	SC8c	SC9
NPV-HP	Economic Benefit / Net Present Value-Hydropower (MUSD)	$69 631	$46 814	$32 312	$56 610	$56 833	$54 847	$54 847	$54 847	$46 628
NPV-IR	Economic Benefit / Net Present Value-Irrigation+fisheries+livestocks (MUSD)	$5 772	$5 772	$8 113	$6 715	$7 547	$6 829	$6 829	$6 829	$6 810
WP	Economic Benefit / Water Productivity - Irrigation (USCents/ha)	$4.11	$4.11	$4.36	$4.15	$4.59	$4.01	$4.01	$4.01	$4.20
Empl	Social / Employment (x1000)	102.32	102.31	115.25	110.26	105.70	111.33	111.33	111.33	108.81
Restl	Social / Number of person resettled (x 1000)	19 941	20 341	19 441	20 341	20 341	20 341	20 341	20 341	20 341
BCM-Eg	Environment / Water Balance (BCM at Delta - Egypt)	8.55	9.54	-9.03	-0.82	-0.82	-3.35	-0.71	0.31	-0.95
Equity	Equity/Reduce Unequaliy from Benefit from water uses (Gini Index)	0.78	0.71	0.64	0.75	0.81	0.76	0.76	0.76	0.71
Evap	General / Total evaporation losses from artificial reservoir (BCM)	-23.87	-22.88	-21.51	-23.54	-23.31	-23.31	-23.31	-23.31	-22.46

Table 3-26 : Normalized indicators (coverted to a s cale of 0 to 10)

	Normalized indicators	SC3	SC5	SC6	SC7a	SC7b	SC8a	SC8b	SC8c	SC9
NPV-HP	Economic Benefit / Net Present Value-Hydropower (MUSD)	10,00	3,89	0,00	6,51	6,57	6,04	6,04	6,04	3,84
NPV-IR	Economic Benefit / Net Present Value-Irrigation+fisheries+livestocks (MUSD)	0,00	0,00	10,00	4,03	7,58	4,52	4,52	4,52	4,43
WP	Economic Benefit / Water Productivity - Irrigation (USCents/ha)	1,72	1,72	6,03	2,41	10,00	0,00	0,00	0,00	3,28
Empl	Social / Employment (x1000)	0,00	0,00	10,00	6,15	2,62	6,97	6,97	6,97	5,03
Restl	Social / Number of person resettled (x 1000)	5,56	10,00	0,00	10,00	10,00	10,00	10,00	10,00	10,00
BCM-Eg	Environment / Water Balance (BCM at Delta - Egypt)	9,47	10,00	0,00	4,42	3,25	3,06	4,48	5,03	4,35
Equity	Equity/Reduce Unequaliy from Benefit from water uses (Gini Index)	8,01	3,84	0,00	6,13	10,00	6,91	6,91	6,91	3,82
Evap	General / Total evaporation losses from artificial reservoir (BCM)	0,00	4,19	10,00	1,40	2,37	2,37	2,37	2,37	5,97

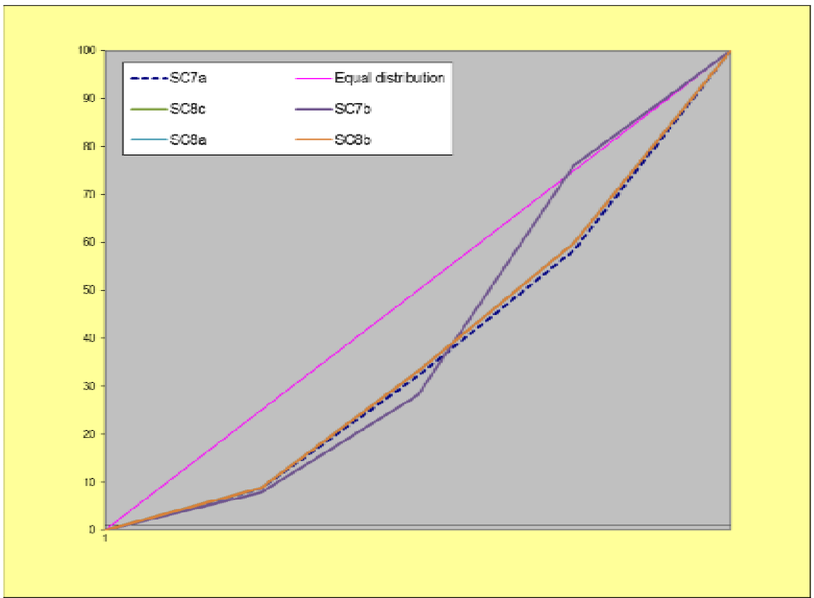
Table 3-27 : Weighted score for scenario

	Multi-Criteria Analysis ranking	SC3	SC5	SC6	SC7a	SC7b	SC8a	SC8b	SC8c	SC9
NPV-HP	Economic Benefit / Net Present Value-Hydropower (MUSD)	0,90	0,35		0,58	0,59	0,54	0,54	0,54	0,34
NPV-IR	Economic Benefit / Net Present Value-Irrigation+fisheries+livestocks (MUSD)			0,00	0,36	0,68	0,41	0,41	0,41	0,40
WP	Economic Benefit / Water Productivity - Irrigation (USCents/ha)	0,32	0,32	0,00	0,45	1,86				0,61
Empl	Social / Employment (x1000)	0,00		0,71	0,43	0,18	0,49	0,49	0,49	0,35
Restl	Social / Number of person resettled (x 1000)	0,61	1,09		1,09	1,09	1,09	1,09	1,09	1,09
BCM-Eg	Environment / Water Balance (BCM at Delta - Egypt)	1,27	1,35		0,60	0,44	0,41	0,60	0,68	0,59
Equity	Equity/Reduce Unequaliy from Benefit from water uses (Gini Index)	1,08	0,52		0,83	1,35	0,93	0,93	0,93	0,51
Evap	General / Total evaporation losses from artificial reservoir (BCM)		0,78	1,86	0,26	0,44	0,44	0,44	0,44	1,11
	Weighted Score	4,2	4,4	2,6	4,6	6,6	4,3	4,5	4,6	5,0

The following comments on the fresults can be made:

- Scenario 1 Base Case, Scenario 2 (IS) and Scenario 4, have not been evaluated with the MCA. The first two scenario were considered as a baseline reference. Scenario 4 (IS + Full irrigation Potential Basin Wide) has been excluded because it is unrealistic and far from the objective of the EN-MSIOA which is to highlight the benefits from cooperation. Actually, Scenario 4 approximately simulates the unilateral development trajectories of each country especially in the agriculture sector. The implementation of this irrigation would result in a deficit of 9 BCM per year at the lower end of the basin.
- Scenario 6 (IS + Large irrigation Potential), with a weighted score of 2.6, also fails to be selected by the MCA. It has the lowest score in gthe MCA. This scenario is highly negative from both the economic and environmental perspectives. Moreover, in terms of Equity, it also has the lowest score.
- Scenario 3, not surprisingly due to its focus on maximising hydropower has the highest NPV of 75 billion USD for HP and irrigation. Its weighted score is broight down to 4.0 as a results of environmental and social issues associated with the reservoirs.
- Scenario 5 is also focussed on hydropower and very limited irrigation expansion and has a relativey high NPV of 51 billion USD. There is also a "surplus" of 9 BCM flow at the delta in Egypt. As a result the weighted score riese to 4.2.
- The remaining scenarios have the highest weighted scores (ranging between 4.3 and 6.6.
  - Scenario 7b scores very highly in several areas, especially those connected to economic benefits associated with irrigation (productivityefficient in UScents/ha). This is because of the much cheaper implementation costs for irrihation expansion in the flatland Sudanes portion of the border.
  - Not surpisingly, Scenarion 8c has the best weighted score for the Scenario 8 choices.
  - Scenario 9 also scores well.
- In conclusion, cognisance will be taken of these results and the insight obtained, in moving forward to the next step. A more detailed examination of Scenarios 7a, 7b, 8a, 8b, 8c and 9 will form the basis of the MSIOA Investment Strategy and Businees Plan.

Figure 3-16: Gini index of benefits from water uses per capita



4. Conclusions and Way Forward

In the next step of the study, the results of this analytical framework report, together with an appreciation of other criteria, will be used to define a *MSIOA investment strategy* and an associated *action plan*. The action plan will therefore be based not only on purely economic reasons but will also take into account other criteria. In particular, the scenario of water development activities analysed in the present report will be supporting the analysis of some prospective scenarios. Based on the foregoing analysis, the key findings of the study can be summarized as follows:

- Water availability **is a major constraint** that limits irrigated agriculture expansion.
- Water productivity from investment in hydropower is about 0.21 US$ per cubic meters which is almost triple the productivity compared to investment in irrigated agriculture (about 0.06 US$ per cubic meters).
- Hence, any trade-off between hydropower versus irrigation (from an economic point of view) gives priority to investments in hydropower.
- There is a comparative advantage among the EN sub-basins when such a trade-off is assessed in the different sub-basins. The Abbay Blue Nile has a higher potential in terms of hydropower, while the potential for irrigated agriculture is comparatively more favourable in Baro-Akobo-Sobat. On the orher hand, the development of irrigation in the lowland of Sudan is generally considerably cheaper and there is more scope for double cropping. Consideration should be given to tap into such potential and comparative advantages among the sub-basin for optimum utilization of the resource base.
- The outcome of the multi-sector scenario analysis showed a potential for growth and win-win regional investment planning but this needs strong political will and commitment from the EN countries to embark on a collaborative effort in planning developments and management of the EN water resources. The benefits from cooperation could be huge while the cost of non-cooperation are potentially disastrous and could lead to instability in the region. The following section summarize the benefits gained by each country and the cost of cooperation that might encountered assuming scenario 9 (IS+ Large Hydro+ Managed Irrigation Growth) to each of the EN state. Scenario 9 is only one of several scearios that could work and it is discussed below by way of illustration. Scenario 9, together with Scenarion 7 and Scenario 8 options will be taken forward to the Investment Strategy and Action Plan step.

Probable Implications of Scenario 9 Implementation on Egypt

- **Benefits:** In the case of scenario 9, it is estimated that a total of about 65,000 ha of new development in the west delta could be pursued and approximately 35,000 ha could be rehabilitated while the water demands for existing schemes could be satisfied with a high level of assurance..
- **Costs:** The cost of cooperation for Egypt is that the HAD might need to be operated at a lower level which could reduce the energy generation from HAD. It is also anticipated such a cost could be mitigated through regional power trade. In addition the implication of implementation of Scenario 9 could significantly reduce the Tushka diversion with such diversion only feasible during high wet years where the yield from the Nile as measured in Aswan excceds 95 BCM/yr .

Probable Implication of Scenario 9 Implementation on Ethiopia

- ***Benefits***: Under this scenario Ethiopia would be able to irrigate around 0.7 million ha in total and generate around 2,573 Gwhr annually.
- **Costs:** The cost of cooperation for Ethiopia could lead to a sovereig strategic decision made by Ethiopia to limit its irrigation expansion in the Abbay river system to about 300,000 ha. This might entail limiting new irrigation development in the Abbay and its tributaries to include about 50,000 ha in Lake Tana, 75,000 ha in Didessa and around 100,000 in Beles. This would also help in maximizing benefits from energy generation for the potential cascade along the Abbay main river stem.

Probable Implication of Scenario 9 Implementation to South Sudan

- **Benefits**: Under Scenario 9, South Sudan would be able to irrigate around 0.12 million ha in total and benefit from the opportunity of regional power trade.
- **Costs**: No direct and tangible cost of cooperation is foreseen for South Sudan apart from its commitment to engage in the intensive monitoring of the complex rivers system in the Sobat and Pibor. However, there would be a strong need and commitment from South Sudan with the Support of ENTRO and/or any other regional cooperation platform for the EN, to develop and implement an integrated water resources management plan for the Sobat and Pibor, that takes into consideration the environmental sensitivity of the basin and could ultimately culminate in the long term sustainability of the wetland system in South Sudan.

Probable Implication of Scenario 9 Implementation to Sudan

- **Benefits:** Under this scenario Sudan would be able to irrigate a total of 0.30 million ha in addition to existing irrigation areas and also offer the opportunity for crop intensification and moving to high value crops and winter cropping as well. In addition, the hydropower generation capacity in Sudan would be lifted from about 8,500 GWhr per base case to about 13,474 GWhr per annum.
- **Costs:** The cost of cooperation for Sudan might require strong commitment for Sudan to embark into a program for irrigation modernization to increase the water use efficiency of existing schemes, and engage in a programme of water savings through coordinated operation of existing reservoirs. This would entail engagement into the regional program for coordinated planning and operation of reservoirs with the possibility of revising the operating rules of reservoirs to minimize evaporation losses. Other impacts could be a loss in recession agriculture and an increase in pumping costs for existing schemes.

It is important to note that the purpose of investigating these scenarios and in selecting Scenario for the draing of the above conlcusions is not to propose precisely Scenario 9 for adoption. The idea is rather to point to Scenario 9 as the one probably closest to representing a realistic way forward and which would provide a narrower point of departure for going forward.

Upon looking at these implications it can be clearly recognized that the **potential benefits occurred from cooperation could highly overweight the costs**. In general, it is poorly informed perception and lack of mutual trust that challenge cooperation. At the same timeHence there is a need for an initiative to be led by ENTRO for the proper packaging and marketing of the necessary investment scenarios in an action plan that could look for investment trajectories in each sub-basin and develop mutually consistent integrated water resources development and management plans in each sub-basin.

ANNEXES

ANNEX A: SUPPORTING INFORMATION FOR CROP WATER REQUIREMENT CALCULATIONS

ANNEX A.1: EGYPT

Unit Water Requirements (m^3/feddan) for Upper Egypt

Crop	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Wheat	0	55	345	352	477	621	493	0	0	0	0	0	2,343
Rice	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize	573	0	0	0	0	0	0	0	0	253	665	752	2,243
Barley	0	76	230	234	298	414	328	0	0	0	0	0	1,580
Sorghum	0	0	0	0	0	0	0	0	215	669	1,022	827	2,733
Vegetables one (winter)	241	521	691	600	0	0	0	0	0	0	0	0	2,053
Vegetables two (summer)	200	0	0	0	0	0	0	0	0	353	489	280	1,322
Fruits	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Bananas	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Citrus	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Grapes	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Soybeans	0	0	0	0	0	0	0	573	943	892	174	0	2,582
Groundnut	0	0	0	0	0	0	281	493	569	536	188	0	2,067
Sesame	0	0	0	0	0	0	0	214	597	648	640	0	2,099
Sunflower	0	0	0	0	0	0	0	214	597	648	640	0	2,099
Olives	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes & Other tubers	0	0	0	0	0	0	0	573	943	892	174	0	2,582
Pulses	0	254	322	258	352	414	0	0	0	0	0	0	1,600
Sugarcane	601	403	325	399	376	592	973	1,138	1,236	1,244	1,084	818	9,189
Sugareats	601	403	325	399	376	592	973	1,138	1,236	1,244	1,084	818	9,189
Fodder	0	421	439	488	557	707	558	0	0	0	0	0	3,170
Cotton	0	0	0	0	0	260	488	695	518	975	712	154	3,802
Flowers	0	0	0	0	0	0	0	0	0	0	0	0	0
WR Per Fed.	**170**	**139**	**153**	**156**	**152**	**221**	**280**	**321**	**414**	**479**	**410**	**251**	**3,147**

Unit Water Requirements (m^3/feddan) for Middle Egypt

Crop	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Wheat	0	0	267	325	382	373	397	0	0	0	0	0	1,744
Rice	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize	530	114	0	0	0	0	0	0	0	253	665	752	2,314
Barley	0	178	217	254	382	265	78	0	0	0	0	0	1,374
Sorghum	0	0	0	0	0	0	0	0	215	669	1,022	827	2,733
Vegetables one (winter)	241	521	691	600	0	0	0	0	0	0	0	0	2,053
Vegetables two (summer)	0	0	0	0	270	560	720	610	0	0	0	0	2,160
Fruits	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Bananas	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Citrus	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Grapes	426	266	212	212	266	373	586	586	667	667	639	533	5,433
Soybeans	0	0	0	0	0	0	0	573	943	892	174	0	2,582
Groundnut	0	0	0	0	0	0	281	493	569	536	189	0	2,068
Sesame	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower	0	0	0	0	0	0	0	214	597	648	640	0	2,099
Olives	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes & Other tubers	0	0	0	0	211	453	623	588	0	0	0	0	1,875
Pulses	0	194	246	313	342	361	0	0	0	0	0	0	1,456
Sugarcane	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugareats	601	403	325	399	376	592	973	1,138	1,236	1,244	1,084	818	9,189
Fodder	0	389	427	410	493	560	314	0	0	0	0	0	2,593
Cotton	0	0	0	0	0	141	268	473	618	711	363	184	2,758
Flowers	0	0	0	0	0	0	0	0	0	0	0	0	0
WR Per Fed.	**134**	**124**	**131**	**137**	**153**	**209**	**261**	**280**	**298**	**331**	**291**	**205**	**2,553**

Crop	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Wheat	0	0	174	177	176	424	444	0	0	0	0	0	1,395
Rice	343	0	0	0	0	0	0	400	1,001	1,089	1,458	1,474	5,765
Maize	464	109	0	0	0	0	0	0	0	248	688	740	2,249
Barley	0	116	118	118	289	296	65	0	0	0	0	0	1,002
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0
Vegetables one (winter)	190	480	530	427	0	0	0	0	0	0	0	0	1,627
Vegetables two (summer)	0	0	0	0	208	412	622	580	0	0	0	0	1,822
Fruits	392	244	197	195	244	344	541	541	613	614	588	491	5,004
Bananas	392	244	197	195	244	344	541	541	613	614	588	491	5,004
Citrus	392	244	197	195	244	344	541	541	613	614	588	491	5,004
Grapes	392	244	197	195	244	344	541	541	613	614	588	491	5,004
Soybeans	0	0	0	0	0	0	0	493	817	791	149	0	2,250
Groundnut	0	0	0	0	0	0	231	420	525	504	188	0	1,868
Sesame	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower	0	0	0	0	0	0	0	0	0	0	0	0	0
Olives	392	244	197	195	244	344	541	541	613	614	588	491	5,004
Potatoes & Other tubers	0	0	0	0	211	454	623	588	0	0	0	0	1,876
Pulses	0	84	229	243	291	340	0	0	0	0	0	0	1,187
Sugarcane	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugareats	601	403	325	399	376	592	973	1,138	1,236	1,244	1,084	818	9,189
Fodder	0	339	372	387	294	559	238	0	0	0	0	0	2,189
Cotton	0	0	0	0	0	120	262	473	615	711	363	184	2,728
Flowers	392	244	197	195	244	344	541	541	613	614	588	491	5,004
WR Per Fed.	**172**	**130**	**127**	**127**	**144**	**229**	**291**	**319**	**342**	**360**	**324**	**268**	**2,834**

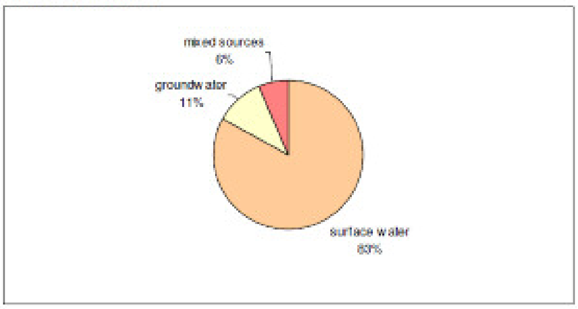
Typical Cropping Pattern Irrigated Sector Eygpt (Source: FAO Database)

Irrigated Crop	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	%
Wheat	0	30	30	30	30	30	30	0	0	0	0	0	17%
Rice	19	0	0	0	0	0	0	0	19	19	19	19	11%
Maize	24	0	0	0	0	0	0	0	24	24	24	24	14%
Barley	0	3	3	3	3	3	3	0	0	0	0	0	2%
Sorghum	5	0	0	0	0	0	0	0	5	5	5	5	3%
Vegetables one (winter)	0	0	0	0	0	10	10	10	10	0	0	0	6%
Vegetables two (summer)	10	0	0	0	0	0	0	0	0	10	10	10	6%
Fruits	6	6	6	6	6	6	6	6	6	6	6	6	3%
Bananas	1	1	1	1	1	1	1	1	1	1	1	1	0%
Citrus	4	4	4	4	4	4	4	4	4	4	4	4	2%
Grapes	2	2	2	2	2	2	2	2	2	2	2	2	1%
Soybeans	0	0	0	0	0	0	0	0	0	0	0	0	0%
Groundnut	0	0	0	0	0	0	0	2	2	2	2	2	1%
Sesame	0	0	0	0	0	0	0	1	1	1	1	1	0%
Sunflower	0	0	0	0	0	0	0	1	1	1	1	1	0%
Olives	1	1	1	1	1	1	1	1	1	1	1	1	1%
Potatoes & other tubers	0	0	0	0	3	3	3	3	3	0	0	0	2%
Pulses	0	0	0	0	0	0	0	5	5	5	5	0	3%
Sugarcane	4	4	4	4	4	4	4	4	4	4	4	4	2%
Sugareats	2	0	0	0	0	0	0	2	2	2	2	2	1%
Fodder	0	35	35	35	35	35	0	0	0	0	0	0	20%
Cotton	9	9	9	9	0	0	0	0	0	9	9	9	5%
Flowers	1	1	1	1	1	1	1	1	1	1	1	1	0%
Total	**88**	**96**	**96**	**96**	**90**	**100**	**65**	**43**	**91**	**97**	**97**	**92**	**100**

aquastat

From: FAO Water Report 29 (2005)

FIGURE 3
Origin of irrigation water
Total: 3 422 178 ha in 2000



ANNEX A.2: ETHIOPIA

(Source: EN Irrigation and Drainage Study by BRL)

GENERAL

The gross irrigation water requirements (GWR) for Abay Basin projects have been calculated in a series of tables using variables such as cropping patterns, rainfall, evapotranspiration, altitudes and irrigation efficiency. The effective rainfall has been calculated with the USBR formula. Rainfall and ET0 values have been corrected for difference in altitudes between project and stations. The irrigation requirements are calculated for an average year. If requirements have to be calculated for a year with dependable rainfall (in 80% of all years exceeded) the effective rainfalls have to be recalculated for instance with the CROPWAT program using files with data on dependable rainfall, calculated according to the usual FAO procedures. For the ENIDS study, only the average GWR are essential.

If cropping pattern no 6 (Lake Tana with rice) is used, net water requirements are increased by 250 mm in January and July to account for land preparation requirements. For all other cropping patterns NWR is increased by 30 mm/ per month during November and December. No specific data could be obtained for the projects in the Tekeze and Baro/Akobo basin to calculate the water requirements according to the procedure described. However, data on GWR have been derived from the Master plan documents.

TABLES

- Table 1 presents the project site, project altitude, the stations used for calculating the rainfall and ET0. The two right columns present the corrections applied to total rainfall and ET0 that take into account the differences in altitude.
- Table 2 and 3 present details on the met stations used for the calculations.
- Table 4 presents the daily ET0 and monthly effective rainfall values for each project site and associated stations.
- Table 5 and 6 show respectively the monthly ET0 values and monthly effective rainfall for each project site.
- Tables 7-13 present the cropping patterns that were adopted during the Abay Master plan Study and subsequent prefeasibility studies.
- Finally, tables 14 and 15 present the monthly, seasonal, and annual GWR.

INTERPRETATION OF RESULTS

The GWR on scheme and on hectare basis are shown for each project in the respective project cost sheets, see Appendix 3. These might differ slightly from the figures presented in tables 14 and 15. This is due to averaging, rounding-off and updating with information obtained from studies implemented after completion of the Abay Basin Master plan. In the case of the Didessa Sub basin projects the GWR have been increased substantially to take into account sugarcane cultivation and the results of water requirement calculations presented in recent reports.

For the purposes of the ENIDS study it has been assumed that the overall water use efficiency at project level does not exceed 50% and that cropping intensity reaches values of 180%, which is very high. Sugarcane could be irrigated by overhead sprinkler thus increasing water use efficiency, on the other hand global experience shows that efficiencies in surface irrigation projects rarely exceed 45%. With a cropping intensity of 180% the calculated GWR represent maximum requirements in years with average rainfall.

TABLE 1:	STATIONS USED, ALTITUDES AND ABSOLUTE CORRECTIONS					
PROJECT	**ALT (masl)**	**STATIONS USED (rain/ ET0)**	**ALT. RAIN**	**ALT ETO**	**CORRECTION RAIN**	**ETO**
TANA SUB BASIN					(IN MM/YEAR)	
- GILGEL VALLEY PROJECTS	1820	MERAWI/ DANGILA	2110	2180	-174	90
- NW LAKE TANA PUMPING	1800	GORGORA/GORGORA	1830	1830	-18	8
- WEST MEGECH PUMP PROJECTS	1800	GORGORA/GORGORA	1830	1830	-18	8
- MEGECH GRAVITY	1840	GORGORA/GORGORA	1830	1830	6	-3
- EAST MEGECH PUMP PROJECTS	1800	GORGORA/GORGORA	1830	1840	-18	10
- NE TANA PUMP PROJECTS	1800	ADDIS ZEMEN/YIFAG	1850	1800	-30	0
- RIBB GRAVITY PROJECTS	1800	WERETA, ADDIS ZEMEN/YIFAG	1850	1800	-30	0
- GUMARA 1870 PROJECTS	1870	WERETA, ADDIS ZEMEN/YIFAG	1850	1800	12	-18
- GUMARA 1850 PROJECTS	1850	WERETA, ADDIS ZEMEN/YIFAG	1850	1800	0	-13
- GUMARA 1810 PROJECTS	1810	WERETA, ADDIS ZEMEN/YIFAG	1850	1800	-24	-3
- JEMA GRAVITY PROJECTS	2000	MERAWI/DANGILA	2110	2180	-66	45
- GILGEL ABBAY I	1800	BAHIR DAR,MERAWI/DANGILA	1900	2180	-60	95
- KOGA PROJECT	1950	MERAWI/DANGILA	2110	2180	-96	58
-SW LAKE TANA PUMPING	1800	BAHIR DAR/BAHIR DAR	1770	1770	18	-8
BELES SUB BASIN						
- UPPER BELES	1150	MESHENTI/PAWI	1000	1053	90	-24
- LOWER BELES	700	MESHENTI/PAWI	1000	1053	-180	88
DEBRE MARKOS SUB BASIN						
- UPPER BIRR	1800	BIRR SHELKO/FINOTE SALAM	1700	1900	60	25
- LOWER BIRR	1450	BIRR SHELKO/FINOTE SALAM	1700	1900	-150	113
- DEBOHILA	1930	BIRR SHELKO/FINOTE SALAM	1700	1900	138	-8
- FETTAM	2270	TILILI/FINOTE SALAM	2570	1900	-180	-93
- AZENA	1650	MENTA WUHA/FINOT SALAM	2000	1900	-210	63
DINDIR SUB BASIN						
- UPPER DINDIR	950	MESHENTI/MANKUSH	1000	990	-30	10
- LOWER DINDIR	600	MESHENTI/MANKUSH	1000	990	-240	98
- GALEGU	650	MESHENTI/MANKUSH	1000	990	-210	85
- RAHAD	625	MESHENTI/MANKUSH	1000	990	-225	91
DABUS SUB BASIN						
- DABUS (H)	1020	ASSOSSA/ASSOSSA	1560	1600	-324	145
DIDESSA SUB BASIN						
- ARJO-DIDESSA	1330	DIDESSA/DIDESSA	1200	1200	78	-33
- NEGESO	1440	SIBUSIRE/DIDESSA	1750	1200	-186	-60
- DABANA	1280	DIDESSA/DIDESSA	1200	1200	48	-20
- DIMTU	1290	DIDESSA/DIDESSA	1200	1200	54	-23
ANGAR SUB BASIN						
- ANGAR	1350	DIDESSA/ANGAR GUTIN	1200	1850	90	125
FINCHAA SUB BASIN						
- AMARTI-NESHE	1460	BAKO SHEWA/FINCHAA	1650	2280	-114	205
- FINCHAA	1500	BAKO SHEWA/FINCHAA	1650	2280	-90	195
GUDER SUB BASIN						
- GUDER	2030	GUDER/FINCHAA	2002	2280	17	63
- ANONU	1400	BAKO SHEWA/FINCHAA	1650	2280	-150	220
- KALE	1380	BAKO SHEWA/FINCHAA	1650	2280	-162	225
JEMMA SUB BASIN						
- DEBRE GURACHA	2600	DESE/DEBRE MARKOS	2500	2400	60	-50

TABLE 2: DETAILS ON SELECTED MET STATIONS			
STATION	PROJECT ALT (MASL)	TOTAL RAIN	TOTAL ET0
GILGEL VALLEY	1820	1572	1225
NW LAKE TANA PUMPING	1800	1101	1373
WEST MEGECH PUMPING	1800	1101	1373
MEGECH GRAVITY	1840	1101	1373
EAST MEGECH PUM	1800	1101	1373
NE TANA PUMPING	1800	1354	1382
RIBB GRAVITY	1800	1295	1382
GUMARA 1870	1870	1295	1382
GUMARA 1850	1850	1295	1382
GUMARA 1810	1810	1295	1382
JEMA GRAVITY	2000	1572	1225
GILGEL ABBAY I	1800	1572	1225
KOGA GRAVITY (ACRES)	1950	1572	1225
SW LAKE TANA PUMPING	1800	1289	1434
UPPER BELES	1150	1322	1466
LOWER BELES	700	1322	1466
MIDDLE BIRR (ACRES)	1800	892	1253
LOWER BIRR	1450	892	1253
DEBOHILA	1930	892	1253
FETTAM	2270	1943	1253
AZENA	1850	1174	1253
UPPER DINDIR	950	1322	1565
LOWER DINDIR	800	1322	1565
GALEGU	650	1322	1565
RAHAD	625	1322	1565
DABUS (H)	1020	1282	1335
ARJO DIDESSA	1330	1482	1363
NEGESO	1440	1359	1363
DABANA	1280	1482	1363
DIMTU	1290	1482	1363
ANGAR	1350	1482	1266
NESHE	1460	1227	1432
FINCHAA	1500	1227	1432
GUDER	2030	1205	1432
ANONU	1400	1227	1432
KALE	1380	1227	1458
DEBRE GURACHA	2600	1175	1369

ANNEX A.3: SUDAN AND SOUTH SUDAN

Unit Water Requirements (m³/ha) for Typical Sudan Central Scheme (Cropping Pattern 1)

Sudan Crop Factors & Meterological Data										
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 1:	0.20	0.00	0.00	0.20	0.20	0.10	0.05	0.00	CI	0.75
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	DOM WR	CWR
Jul	0.14	0.00		0.54	0.14	0.07	0.18	0.00	0.00	1.07
Aug	0.31	0.00		0.72	0.72	0.02	0.14	0.00	0.00	1.91
Sep	1.22	0.00		1.22	1.22	0.34	0.28	0.00	0.00	4.29
Oct	1.71	0.00		1.13	1.13	0.71	0.32	0.00	0.00	5.00
Nov	1.77	0.00	0.00			0.74	0.35	0.00	0.00	2.85
Dec	1.21	0.00	0.00			0.67	0.30		0.00	2.19
Jan	1.08	0.00	0.00			0.67	0.31		0.00	2.06
Feb	1.03	0.00	0.00			0.73	0.33		0.00	2.09
Mar		0.00				0.62	0.36		0.00	0.98
Apr		0.00				0.41	0.39		0.00	0.81
May		0.00					0.39		0.00	0.39
Jun		0.00		0.59			0.30		0.00	0.89
Annual	8.47	0.00	0.00	4.21	3.21	4.99	3.65	0.00	0.00	1,051

Unit Water Requirements (m³/ha) for Typical Sudan Sugar Scheme (Cropping Pattern 2)

Sudan Crop Factors & Meterological Data										
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 1:	0.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	CI	80.00
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	DOM WR	CWR
Jul	0.00	379.10		0.00	0.00	0.00	0.00	0.00	0.00	379.10
Aug	0.00	344.00		0.00	0.00	0.00	0.00	0.00	0.00	344.00
Sep	0.00	489.60		0.00	0.00	0.00	0.00	0.00	0.00	489.60
Oct	0.00	625.81		0.00	0.00	0.00	0.00	0.00	0.00	625.81
Nov	0.00	589.33	0.00			0.00	0.00	0.00	0.00	589.33
Dec	0.00	539.35	0.00			0.00	0.00		0.00	539.35
Jan	0.00	539.35	0.00			0.00	0.00		0.00	539.35
Feb	0.00	587.59	0.00			0.00	0.00		0.00	587.59
Mar		619.15				0.00	0.00		0.00	619.15
Apr		661.33				0.00	0.00		0.00	661.33
May		650.32					0.00		0.00	650.32
Jun		570.40		0.00			0.00		0.00	570.40
Annual	0.00	6,595.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	282,657

Unit Water Requirements (m³/ha) for Typical Sudan Livestock Scheme (Cropping Pattern 3)

Sudan Crop Factors & Meterological Data										
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 1:	0.00	0.00	0.00	0.00	0.00	0.00	80.00	0.00	CI	80.00
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	DOM WR	CWR
Jul	0.00	0.00		0.00	0.00	0.00	280.22	0.00	0.00	280.22
Aug	0.00	0.00		0.00	0.00	0.00	224.90	0.00	0.00	224.90
Sep	0.00	0.00		0.00	0.00	0.00	441.99	0.00	0.00	441.99
Oct	0.00	0.00		0.00	0.00	0.00	517.42	0.00	0.00	517.42
Nov	0.00	0.00	0.00			0.00	559.87	0.00	0.00	559.87
Dec	0.00	0.00	0.00			0.00	483.62		0.00	483.62
Jan	0.00	0.00	0.00			0.00	492.61		0.00	492.61
Feb	0.00	0.00	0.00			0.00	528.83		0.00	528.83
Mar		0.00				0.00	577.86		0.00	577.86
Apr		0.00				0.00	628.27		0.00	628.27
May		0.00					617.29		0.00	617.29
Jun		0.00		0.00			486.80		0.00	486.80
Annual	0.00	0.00	0.00	0.00	0.00	0.00	5,839.67	0.00	0.00	250,272

Unit Water Requirements (m³/ha) for Typical Sudan Scheme
(Cropping Pattern 4: Summer)

Sudan Crop Factors & Meterological Data										
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 4:	15.00	0.00	0.00	15.00	15.00	12.00	5.00	0.00	CI	62.00
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	DOM WR	CWR
Jul	10.40	0.00		40.74	10.40	8.32	17.51	0.00	0.00	87.38
Aug	23.27	0.00		54.19	54.19	2.13	14.06	0.00	0.00	147.85
Sep	91.80	0.00		91.80	91.80	40.48	27.62	0.00	0.00	343.50
Oct	128.23	0.00		84.68	84.68	85.16	32.34	0.00	0.00	415.08
Nov	132.60	0.00	0.00			88.40	34.99	0.00	0.00	255.99
Dec	91.02	0.00	0.00			80.90	30.23		0.00	202.15
Jan	80.90	0.00	0.00			80.90	30.79		0.00	192.59
Feb	77.12	0.00	0.00			88.14	33.05		0.00	198.31
Mar		0.00				74.29	36.12		0.00	110.41
Apr		0.00				49.60	39.27		0.00	88.87
May		0.00					38.58		0.00	38.58
Jun		0.00		44.25			30.43		0.00	74.68
Annual	635.34	0.00	0.00	315.66	241.07	598.33	364.98	0.00	0.00	92,374

Unit Water Requirements (m³/ha) for Typical Sudan Central Scheme
(Cropping Pattern 5: Summer+Winter)

Sudan Crop Factors & Meterological Data										
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 5:	12.00	0.00	25.00	13.00	15.00	12.00	3.00	0.00	CI	80.00
Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	DOM WR	CWR
Jul	8.32	0.00		35.31	10.40	8.32	10.51	0.00	0.00	72.87
Aug	18.62	0.00		46.97	54.19	2.13	8.43	0.00	0.00	130.34
Sep	73.44	0.00		79.56	91.80	40.48	16.57	0.00	0.00	301.85
Oct	102.58	0.00		73.39	84.68	85.16	19.40	0.00	0.00	365.21
Nov	106.08	0.00	92.08			88.40	21.00	0.00	0.00	307.56
Dec	72.81	0.00	151.69			80.90	18.14		0.00	323.55
Jan	64.72	0.00	185.40			80.90	18.47		0.00	349.50
Feb	61.70	0.00	91.81			88.14	19.83		0.00	261.48
Mar		0.00				74.29	21.67		0.00	95.96
Apr		0.00				49.60	23.56		0.00	73.16
May		0.00					23.15		0.00	23.15
Jun		0.00		38.35			18.26		0.00	56.61
Annual	508.27	0.00	520.99	273.57	241.07	598.33	218.99	0.00	0.00	101,196

Unit Water Requirements (m^3/ha) for Typical Sudan Central Scheme (Cropping Pattern 6: Diversification)

Sudan Crop Factors & Meterological Data

Month	Cotton	Sugar	Wheat	Groundnuts	Sorghum	Veget.	Fodder	Prennials	Effective Rain	ET0
Jul	0.50	1.10		0.80	0.50	0.50	0.92	0.92	2.68	6.74
Aug	0.70	1.10		1.00	1.00	0.50	0.88	0.88	3.26	6.87
Sep	1.10	1.10		1.10	1.10	0.70	1.01	1.01	1.43	6.87
Oct	1.20	1.10		0.80	0.80	1.00	0.91	0.91	0.16	7.26
Nov	1.20	1.00	0.50			1.00	0.95	0.95	0.00	7.37
Dec	0.90	1.00	0.90			1.00	0.90	0.90	0.00	6.74
Jan	0.80	1.00	1.10			1.00	0.91	0.91	0.00	6.74
Feb	0.70	1.00	0.50			1.00	0.90	0.90	0.00	7.34
Mar		1.00				0.80	0.93	0.93	0.00	7.74
Apr		1.00				0.50	0.95	0.95	0.00	8.27
May		1.00					0.95	0.95	0.13	8.26
Jun		1.10		0.50			0.95	0.95	0.53	6.97
Cropping Pattern 6:	10.00	5.00	25.00	10.00	15.00	15.00	5.00	15.00	CI	100.00
Month	**Cotton**	**Sugar**	**Wheat**	**Groundnuts**	**Sorghum**	**Veget.**	**Fodder**	**Prennials**	**DOM WR**	**CWR**
Jul	6.94	23.69		27.16	10.40	10.40	17.51	52.54	0.00	148.65
Aug	15.52	21.50		36.13	54.19	2.66	14.06	42.17	0.00	186.23
Sep	61.20	30.60		61.20	91.80	50.60	27.62	82.87	0.00	405.90
Oct	85.48	39.11		56.45	84.68	106.45	32.34	97.02	0.00	501.53
Nov	88.40	36.83	92.08			110.50	34.99	104.98	0.00	467.78
Dec	60.68	33.71	151.69			101.13	30.23		0.00	377.44
Jan	53.94	33.71	185.40			101.13	30.79		0.00	404.97
Feb	51.41	36.72	91.81			110.17	33.05		0.00	323.17
Mar		38.70				92.86	36.12		0.00	167.68
Apr		41.33				62.00	39.27		0.00	142.60
May		40.65					38.58		0.00	79.23
Jun		35.65		29.50			30.43		0.00	95.58
Annual	423.56	412.21	520.99	210.44	241.07	747.91	364.98	379.57	0.00	**141,460**

ANNEX B: SUPPORTING INFORMATION FOR COSTING IRRIGATION PROJECTS

B.1 INVESTMENT COSTS

B.1.1 Estimate of Infrastructure Cost Per Unit Feddan Egypt

Estimate of Infrastructure Investment Cost Per Feddan					
Cost Component	PY1	PY2	PY3	Total	Cost US$/feddan
Intakes	155.38	138.11	51.79	345.27	345.27
Pumping: Boosters (Intermediate and Sub-Main)	119.40	252.12	259.32	630.84	630.84
Electricity Supply	66.74	59.23	22.25	148.23	148.23
Mains	101.36	101.36	50.68	253.40	253.40
Sub-Mains	18.84	37.67	37.67	94.17	94.17
Farm Connections	25.00	50.01	50.01	125.01	125.01
Crossing Structures	10.47	20.93	73.28	104.68	104.68
Roads System	12.33	24.65	86.28	123.25	123.25
Working Capital	1.42	4.24	8.47	14.13	14.13
Sub-total	**510.92**	**688.30**	**639.75**	**1,838.98**	**1,838.98**
Physical Contingencies (5%)	25.55	34.42	31.99	91.95	91.95
Price Contingencies (5%)	25.55	34.42	31.99	91.95	91.95
Total Contingencies (10%)	51.09	68.83	63.98	183.90	183.90
Sub-Total Pre Interest During Construction	**562.02**	**757.13**	**703.73**	**2,022.88**	**2,022.88**
Interest During Construction (3%)	16.86	22.71	21.11	60.69	60.69
Commission on Bond (1%)	5.62	7.57	7.04	20.23	20.23
Total Initial Investment Cost Per Feddan	**584.50**	**787.42**	**731.88**	**2,103.79**	**2,103.79**
Total Initial Investment Cost Per hectare	**1,391.66**	**1,874.81**	**1,742.56**	**5,009.03**	**5,009.03**

Source: WB-PAD for Egypt West Delta Irrigation Project

B.1.2 Estimate of Infrastructure Cost Per Unit Feddan (Sudan & South Sudan)

Estimate of Initial Investment Cost Per Feddan	
Item Description	Cost US$/feddan
Building,construction and Civil Work	287.50
Agriculture Machineries	112.50
Harvesting Machinery	210.00
Workshop Equipments	180.00
Waste Water Treatment Unit	50.00
Communication, IT Equipments & Furniture	12.50
Vehicles	17.50
Rehabilitation of Existing Irrigation Systems and Networks (canals, equipment, pump station and civil work	500.00
Construction of New Irrigation Systems and Networks (canals, equipment, pump station and civil work	1,000.00
Pre-operating Expenses	37.50
Sugar Factory and Ethanol Plant	2,865.00
Total Initial Investment Cost Per Feddan	US$/fed
Total Initial Investment Cost Per hectare	US$/ha

Source: Sudan Agro-Industry Investment Opportunity

B.1.3 Estimate of Project Infrastructure Unit Cost (Ethiopia)

Project: UPPER BELES		Net irrigable area:	**53,720** ha
Code: BEL1		Unit costs:	**679** U$/ha
WR	9,900 m3/ha	GWR 532 MCM	

No	Description	Unit	Quant.	Unit cost ('000 Birr)	Costs (million Birr)
1	**Headworks**				
	Weir, 3 m high, 50 m long, river depth = 5 m	unit	1	1,632.7	0.2
	Intake left bank, Q= 20 m3/s	unit	1	255.1	0.0
	Intake right bank, Q= 20 m3/s	unit	1	255.1	0.0
	Civil works Pumping station 1 Q= 0 m3/s	ls	0	0.0	0.0
	Civil works Pumping station 2 Q= 0 m3/s	ls	0	0.0	0.0
	Civil works Pumping station 3 Q= 0 m3/s	ls	0	0.0	0.0
	Equipment station 1 Q= 0 m3/s Hdyn= 0 m	ls	0	0.0	0.0
	Equipment station 2 Q= 0 m3/s Hdyn= 0 m	ls	0	0.0	0.0
	Equipment station 3 Q= 0 m3/s Hdyn= 0 m	ls	0	0.0	0.0
	Pipeline station 1, L= 0 m diam= 0 m, steel	unit	0	0.0	0.0
	Pipeline station 2, L= 0 m diam= 0 m, steel	unit	0	0.0	0.0
	Pipeline station 3, L= 0 m diam= 0 m, steel	m	0	0.0	0.0
2	**Main irrigation canal (incl road)**				
	Unlined vertisols (Right bank) Qini= 20.0 m3/s Qav= 0 m3/s	m	123,000	0.2	2.6
	Concrete lined (Right bank) Qini= 20.0 m3/s Qav 0 m3/s	m	20,000	0.4	0.8
	Unlined vertisols (Left bank) Qini= 20.0 m3/s Qav 0 m3/s	m	124,000	0.2	2.6
	Concrete lined (Left bank) Qini= 20.0 m3/s Qav 0 m3/s	m	20,000	0.4	0.8
	Automatic WL control	ls	1	3,061.2	0.3
	Structures 15 % of main canal costs				1.0
3	**Secondary irrigation system**				
	Secondary canals including structures and roads	ha	53,720	0.3	1.7
	Night storage reservoirs	ha	53,720	0.1	0.6
4	**Tertiary irrigation and drainage system**				
	Irrigation and drainage systems, sloping area 4-7%	ha	53,720	1.2	6.7
	Irrigation and drainage systems, flat area 0-3%	ha	0	0.8	0.0
	Land clearing&land leveling, dense bush	ha	0	1.4	0.0
	Land clearing&land leveling, medium	ha	53,720	0.9	4.7
	Land clearing&land leveling, light bush	ha	0	0.3	0.0
5	**Main and secondary drainage system/flood protection**				
	Main drains	000 m3	0	0.0	0.0
	Structures 15 % of main drain costs	ls	0	0.0	0.0
	Flood protection	ha	53,720	0.0	0.1
	Flood protection dyke	ml	0	0.0	0.0
6	**Miscellaneous**				
	Transmission line, 15 kV	km	0	30.6	0.0
	Transmission line, 66 kV	km	0	40.8	0.0
	Accessroad	km	100	18.4	0.2
	Office and staff housing facilities	ha	53,720	0.3	1.7
	Sub total, including 15% preliminaries				**27.6**
	Physical contingencies 20 %				5.5
	Sub-total				33.1
	Engineering 5 %				1.7
	Sub-total				34.8
	Price contingencies 5 %				1.7
	Grand total				**36.5**

Source: ENIDS Study: Diagnostic Component Final Report

B.2 Recurrent COSTS

B.2.1 Estimate of Power & energy requirements of pumping stations

Power and energy requirement calculations for pumping stations have been based on the following assumptions:

- Power requirement: P = 10 x Q x H/eff, where
    - P = power requirement in kW;
    - Q = discharge in m^3/s;
    - H = design discharge head in m = 1.2 x (static discharge head + headlosses in pipes. Note: 20% allowed for wear and tear in pump and drivers during service life);
    - eff = overall efficiency of pumps and drivers = 0.7
- Energy requirement: E = P x n , with n = V/(Q x 60 x 60), where
    - E = energy requirement in kWh;
    - P = power requirement in kW;
    - n = number of pumping hours per year
    - V = annual volume lifted in m^3

The annual operation costs have been calculated on ha basis showing energy costs (pumping) and other (staffing etc.). Maintenance costs will be shown for pumping equipment, canals, roads and structures and calculated as percentage of investment costs.

The operation and maintenance costs vary according to the type of the project and are generally comprising the following items:

- Maintenance of civil works (weirs, buildings etc) : 0,5% of investment costs (IC)
- maintenance of canals: 0,5% of IC
- maintenance of structures: 1% of IC
- maintenance of mechanical and electrical equipment: 2% of overall investment costs for electrical and mechanical equipment.
- electricity costs: depending on required lift, water requirements and kWh price, (see unit rates Ethiopia and Sudan).
- Staff costs : have not been included.

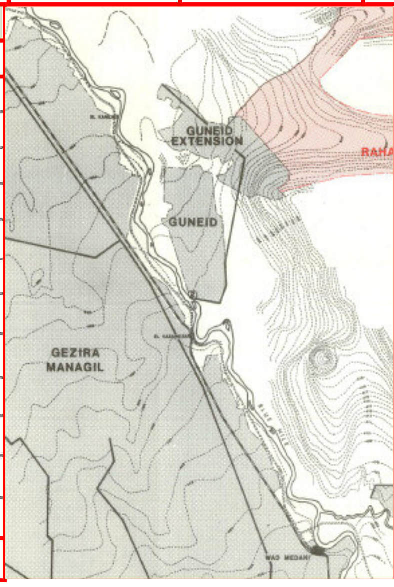
Other assumptions :

- *contingencies*: contingencies have been included to cover unforeseen price and physical increases. For the ENIDS estimates physical and price contingencies amount to 20% and 5% of the base costs respectively;
- *design, engineering, administration and project management*: these items require an additional 5% of the sum of base costs and contingencies and cover items such as prefeasibility, feasibility and detailed design by consultants, aerial photography and mapping, and construction supervision by consultants; project management by the Client is not included.

B.2.2 Sample of Pumping Requirements Calculations: (Guneid Sugar Scheme-Sudan)

Input Data Requirements				
Irrigation Water Supply	*CS*	*IS*	*LDI*	*FDP*
Irrigation Efficiency	70.0	70.0	70.0	70.0
Capacity of Conveyance (cms)	32.0	32.0	48.0	48.0
Domestic & Livestocks WSR (mcm/day)	0.0	0.0	0.0	0.0
Water Delivery Requirements	*CS*	*IS*	*LDI*	*FDP*
FSL at Pump Outlet	394.0	394.0	394.0	394.0
No of Pumps	4.0	4.0	4.0	4.0
Capacity of Pumps (cms)	8.0	8.0	12.0	12.0
Pump Efficiency	70.0	70.0	70.0	70.0

Average Monthly Water Abstraction from BN		
Month	mcm/month	WL
July	18.21	383.80
Aug	14.55	387.93
Sep	18.78	387.82
Oct	22.06	386.43
Nov	21.31	383.96
Dec	19.89	381.98
Jan	16.47	380.36
Feb	14.49	380.16
Mar	17.61	380.01
Apr	19.02	382.02
May	20.38	381.44
Jun	20.48	381.89
Annual	223.2	383.2



2.2.1 Power and energy requirements of pumping stations

HS	15.0	15.0	15.0	15.0	m
HD	17.3	17.3	17.3	17.3	m
Required No of Pumps	4.0	4.0	4.0	4.0	
Installed Capacity	8	8	12	12	cms
Pump Efficiency (%)	70.00	70.00	70.00	70.00	
Electricity charge (Per MWhr)			=	70	US$

Month	Actual Total Head (m)	Required Pumped Water Q (mcm/d)				Pumping Hrs Per Day				Energy (Mwhr)			
		CS	IS	LDI	FDP	CS	IS	LDI	FDP	CS	IS	LDI	FDP
Jan	17.25	0.27	0.27	0.81	0.88	3	3	7	7	557	557	1130	1229
Feb	17.25	0.29	0.29	0.88	0.96	4	4	7	8	605	605	1227	1335
Mar	17.25	0.28	0.28	0.89	0.97	4	4	7	8	595	595	1236	1350
Apr	17.25	0.27	0.27	0.88	0.96	3	3	7	8	567	567	1220	1342
May	17.25	0.21	0.21	0.74	0.83	3	3	6	7	447	447	1030	1150
Jun	17.25	0.19	0.19	0.63	0.71	2	2	5	6	395	395	882	987
Jul	17.25	0.17	0.22	0.43	0.48	2	3	4	4	345	450	602	672
Aug	17.25	0.26	0.18	0.37	0.42	3	2	3	3	545	370	516	580
Sep	17.25	0.45	0.36	0.65	0.72	6	4	5	6	932	750	910	1000
Oct	17.25	0.52	0.52	0.90	0.99	6	6	7	8	1083	1080	1256	1371
Nov	17.25	0.29	0.52	0.89	0.97	4	6	7	8	607	1092	1243	1351
Dec	17.25	0.27	0.47	0.81	0.88	3	6	7	7	557	986	1126	1226
Annual	17.25	104	113	267	293	3.58	3.91	6.13	6.73	7235.45	7893.90	12379.19	13593.68
Pumping Cost (US$/Year)										506,481	552,573	866,543	951,557

ANNEX C: SUPPORTING INFORMATION FOR ECONOMIC ANALYSIS OF IRRIGATION INVESTMENTS

Estimate of initial Investment and Recurrent Cost (Sample the Case of Es-Suki Project Sudan)

SCENARIO	Gross water requirement irrigation	NCA	total investment costs infrastructure	total recurrent cost infrastructure	electricity charges pumping stations	total investment costs infrastructure	total recurrent cost infrastructure
	MCM/year	ha	US$/ha	US$/ha	US$/year	US$/year	US$/year
CS	415.53	36,506	89.29	36.37	1,683	3,259,500	1,327,703
IS	427.19	36,506	2,047.62	36.37	1,690,963	74,751,200	1,327,703
LD1	342.09	36,506	5,862.53	36.41	710,339	214,019,900	1,329,302
FDP	342.09	36,506	5,862.53	36.41	710,339	214,019,900	1,329,302

Estimate of Production Cost for each project under different development options (Sample the Case of Es-Suki Project Sudan):

CROP	EXISTING		IS		LDI		FDP	
	US$/Fed	US$/HA	US$/Fed	US$/HA	US$/Fed	US$/HA	US$/Fed	US$/HA
Cotton	391.65	932.50	373.00	888.10	373.00	888.10	373.00	888.10
Sugar	431.43	1,027.21	431.43	1,027.21	431.43	1,027.21	431.43	1,027.21
Wheat	195.83	466.25	186.50	444.05	186.50	444.05	186.50	444.05
Groundnut	276.68	658.75	263.50	627.38	263.50	627.38	263.50	627.38
Sorghum	141.23	336.25	134.50	320.24	134.50	320.24	134.50	320.24
Vegetables	391.65	932.50	373.00	888.10	373.00	888.10	373.00	888.10
Rice	0.00	0.00	0.00		0.00		0.00	
Fodder	212.10	505.00	202.00	480.95	202.00	480.95	202.00	480.95
Kenaf	0.00	0.00	0.00		0.00		0.00	
Sunflower	143.33	341.25	136.50	325.00	136.50	325.00	136.50	325.00
Sesame	141.23	336.25	134.50	320.24	134.50	320.24	134.50	320.24

Scheme Productivity Based on Aerage Yield under existing and future development scenarios (Sample the Case of Es-Suki Project Sudan)

CROP	CS YIELD	IS	LDI	FDP
PRODUCTIVITY	TON/HA	TON/HA	TON/HA	TON/HA
Cotton	1.22	1.52	1.52	1.52
Sugar	11.25	11.25	11.25	11.25
Wheat	1.52	1.90	1.90	1.90
Groundnut	2.28	2.85	2.85	2.85
Sorghum	1.83	2.29	2.29	2.29
Vegetables	4.56	5.20	5.20	5.70
Rice	2.94	3.00	3.00	3.68
Fodder	0.64	0.80	0.80	0.80
Kenaf	0.00	0.00	0.00	0.00
Sunflower	0.92	1.14	1.14	1.14
Sesame	0.92	1.14	1.14	1.14
Yield Over		2.11	3.00	3.00

Farm gate prices for each crop and (Sample the Case of Es-Suki Project Sudan)

CROP	US$/ton
Cotton	590.50
Sugar	650.00
Wheat	318.50
Groundnut	342.00
Sorghum	214.00
Vegetables	400.00
Rice	
Fodder	1,584.00
Kenaf	450.00
Sunflower	332.50
Sesame	667.00

Net Revenue generated under possible future development levels (Sample Es-Suki Scheme : Sudan)

Net Revenue per Ha			
Without P	IS	LDI	FDP
0	2	0.00	0.00
0	0	1,735.47	1,735.47
1	53	0.00	0.00
16	57	0.00	0.00
16	28	0.00	0.00
61	163	0.00	0.00
0	0	0.00	0.00
42	22	0.00	0.00
0	0	0.00	0.00
0	0	0.00	0.00
0	0	0.00	0.00
86.41	324.53	1,735.47	1,735.47

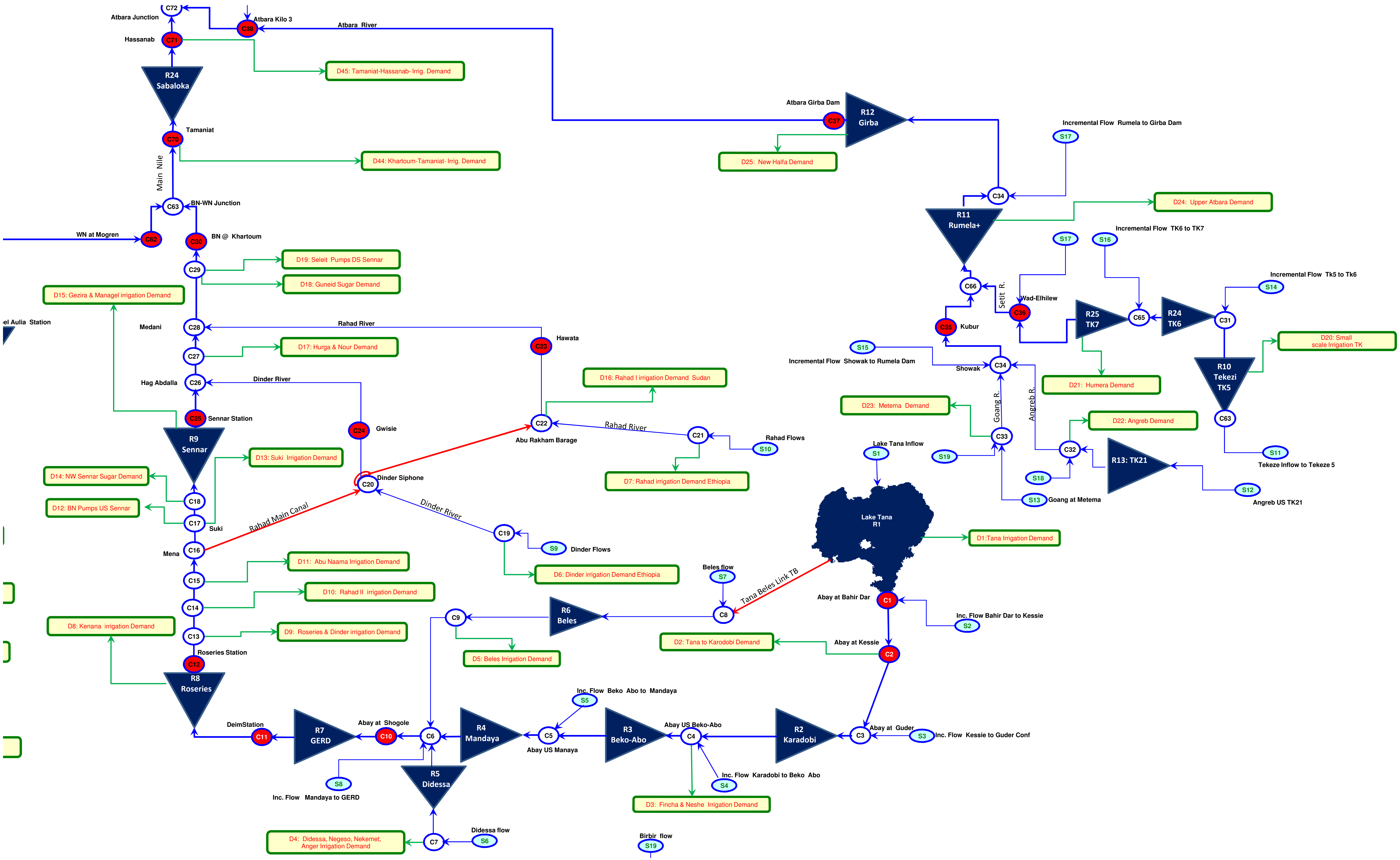
ANNEX D: SCHEMATICS FOR WATER RESOURCES MODELLING

Annex D1: Schematic of the entire EN system

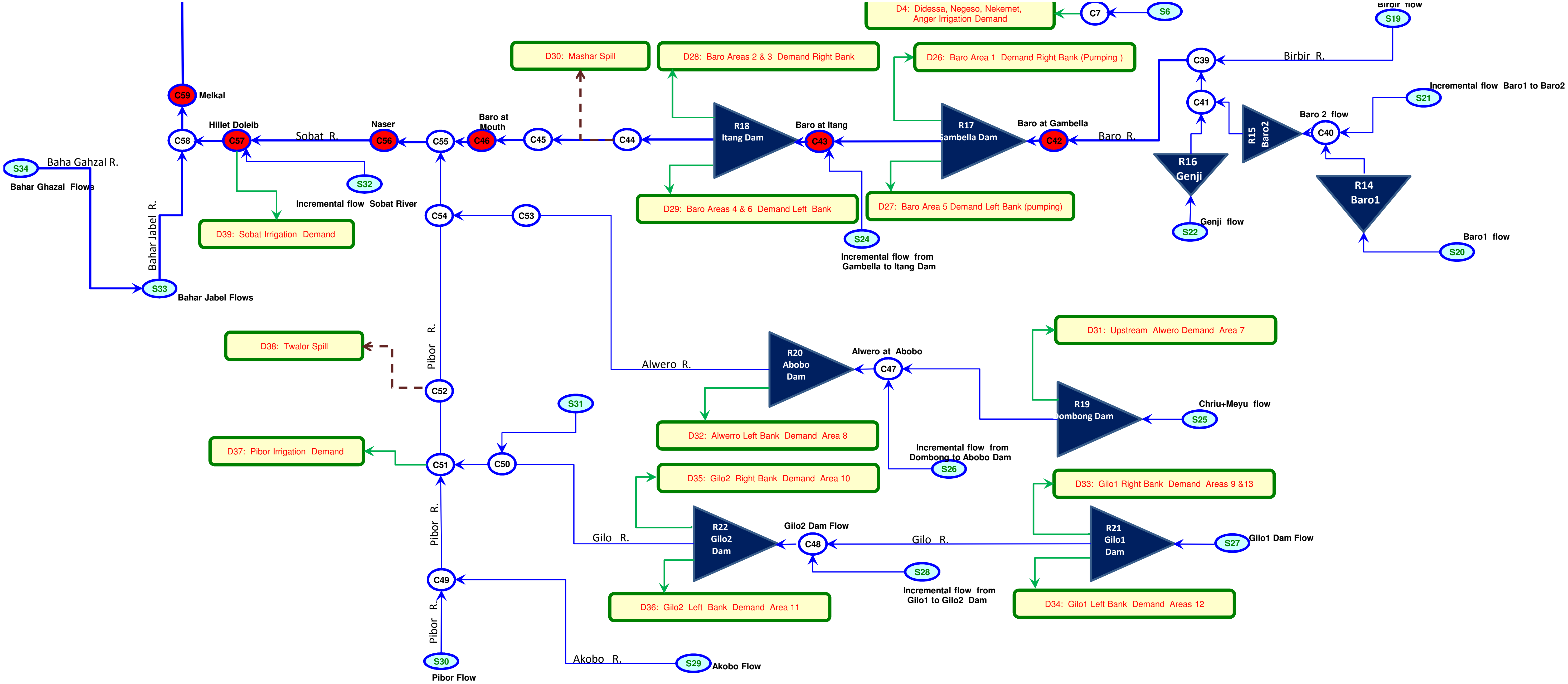
Annex D2: Schematic of the Abbay – Blue Nile AND Tekeze-Setit-Atbara Sub-systems

Annex D3: Schematic of the Baro – Akobo – Sobat Sub-system

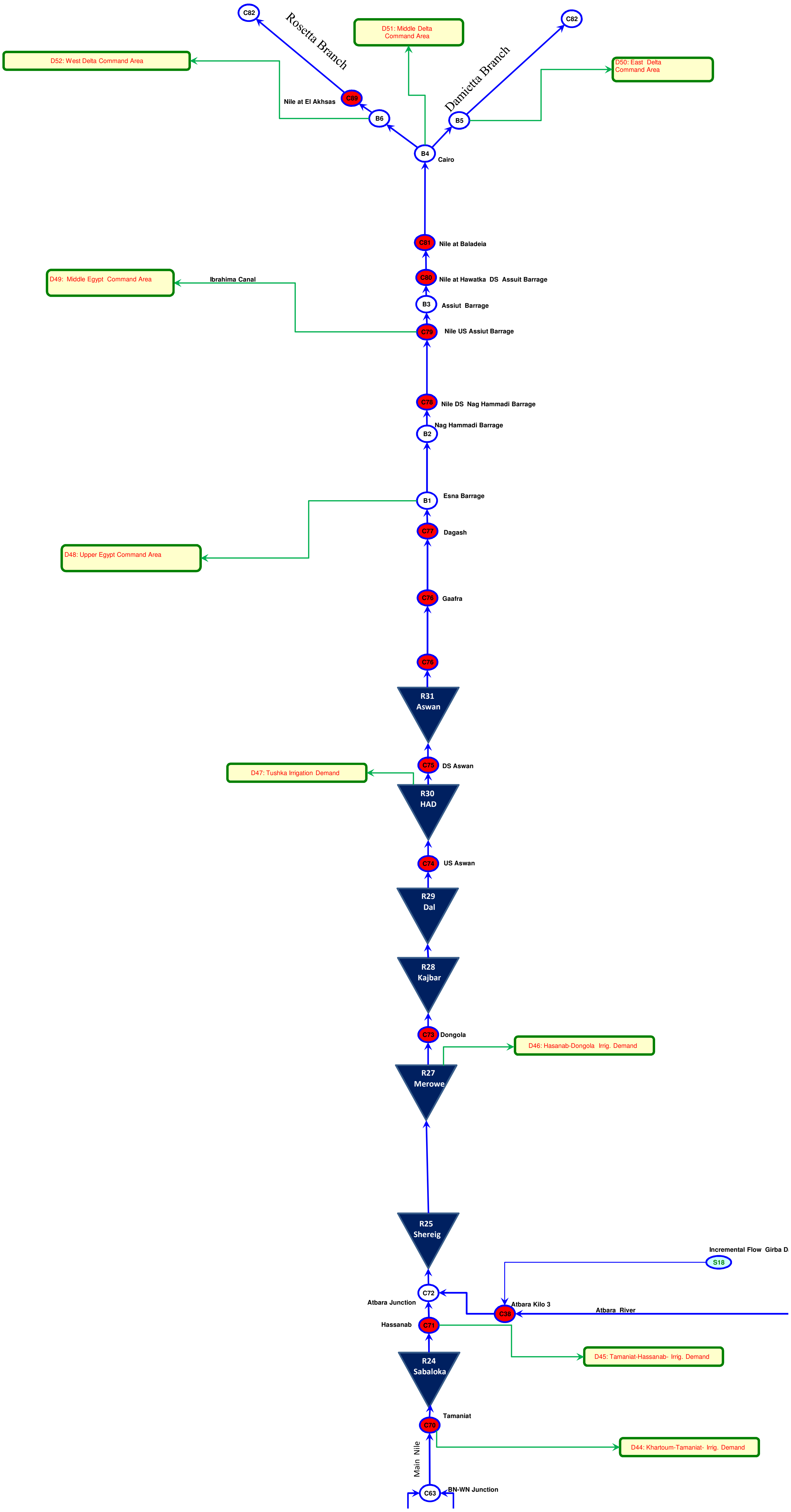
Annex D4: Main Nile Sub-system



C72
Atbara Junction
Atbara Kilo 3
C38
Atbara River
Hassanab
C71
D45: Tamaniat-Hassanab- Irrig. Demand
R24
Sabaloka
Tamaniat
C70
D44: Khartoum-Tamaniat- Irrig. Demand
Main Nile
C63
BN-WN Junction
WN at Mogren
C62
C30
BN @ Khartoum
C29
D19: Seleit Pumps DS Sennar
D18: Guneid Sugar Demand
D15: Gezira & Managel irrigation Demand
el Aulia Station
Medani
C28
Rahad River
C27
D17: Hurga & Nour Demand
Hag Abdalla
C26
Dinder River
C23
Hawata
C25
Sennar Station
R9
Sennar
C24
Gwisie
D13: Suki Irrigation Demand
D14: NW Sennar Sugar Demand
C18
D12: BN Pumps US Sennar
C17
Suki
C16
Mena
Rahad Main Canal
C20
Dinder Siphone
Dinder River
C19
S9
Dinder Flows
D6: Dinder irrigation Demand Ethiopia
C22
Abu Rakham Barage
Rahad River
C21
Rahad Flows
S10
D16: Rahad I irrigation Demand Sudan
D7: Rahad irrigation Demand Ethiopia
C15
D11: Abu Naama Irrigation Demand
C14
D10: Rahad II irrigation Demand
D8: Kenana irrigation Demand
C13
D9: Roseries & Dinder irrigation Demand
Roseries Station
C12
R8
Roseries
DeimStation
C11
R7
GERD
Abay at Shogole
C10
C6
R4
Mandaya
C9
D5: Beles Irrigation Demand
R6
Beles
C8
Beles flow
S7
Tana Beles Link TB
S8
Inc. Flow Mandaya to GERD
R5
Didessa
C7
Didessa flow
S6
D4: Didessa, Negeso, Nekemet, Anger Irrigation Demand
Inc. Flow Beko Abo to Mandaya
S5
C5
Abay US Manaya
R3
Beko-Abo
Abay US Beko-Abo
C4
Inc. Flow Karadobi to Beko Abo
S4
D3: Fincha & Neshe Irrigation Demand
Birbir flow
S19
R2
Karadobi
C3
Abay at Guder
S3
Inc. Flow Kessie to Guder Conf
D2: Tana to Karodobi Demand
Abay at Kessie
C2
Abay at Bahir Dar
C1
Inc. Flow Bahir Dar to Kessie
S2
Lake Tana
R1
Lake Tana Inflow
S1
D1:Tana Irrigation Demand
Atbara Girba Dam
C37
R12
Girba
D25: New Halfa Demand
Incremental Flow Rumela to Girba Dam
S17
C34
R11
Rumela+
D24: Upper Atbara Demand
Incremental Flow TK6 to TK7
S17
S16
C66
Setit R.
Wad-Elhilew
C36
C35
Kubur
R25
TK7
C65
R24
TK6
C31
Incremental Flow Tk5 to Tk6
S14
D20: Small scale Irrigation TK
S15
Incremental Flow Showak to Rumela Dam
Showak
C34
D21: Humera Demand
R10
Tekezi
TK5
D23: Metema Demand
Goang R.
Angreb R.
C33
D22: Angreb Demand
C63
S19
C32
R13: TK21
S11
Tekeze Inflow to Tekeze 5
S18
S13
Goang at Metema
S12
Angreb US TK21



D4: Didessa, Negeso, Nekemet, Anger Irrigation Demand
C7
S6
Birbir flow
S19
D30: Mashar Spill
D28: Baro Areas 2 & 3 Demand Right Bank
D26: Baro Area 1 Demand Right Bank (Pumping)
C39
Birbir R.
Incremental flow Baro1 to Baro2
S21
C59
Melkal
C41
Hillet Doleib
Sobat R.
Naser
Baro at Mouth
R18 Itang Dam
Baro at Itang
R17 Gambella Dam
Baro at Gambella
Baro R.
Baro 2 flow
R15 Baro2
C40
C58
C57
C56
C55
C46
C45
C44
C43
C42
R16 Genji
R14 Baro1
S34
Baha Gahzal R.
S32
Bahar Ghazal Flows
Incremental flow Sobat River
D29: Baro Areas 4 & 6 Demand Left Bank
D27: Baro Area 5 Demand Left Bank (pumping)
C54
C53
Bahar Jabel R.
D39: Sobat Irrigation Demand
S24
Genji flow
S22
Baro1 flow
S20
Incremental flow from Gambella to Itang Dam
S33
Bahar Jabel Flows
D31: Upstream Alwero Demand Area 7
D38: Twalor Spill
Pibor R.
R20 Abobo Dam
Alwero at Abobo
Alwero R.
C47
C52
R19 Dombong Dam
Chriu+Meyu flow
S25
S31
D32: Alwero Left Bank Demand Area 8
D37: Pibor Irrigation Demand
C51
C50
Incremental flow from Dombong to Abobo Dam
S26
D35: Gilo2 Right Bank Demand Area 10
D33: Gilo1 Right Bank Demand Areas 9 &13
Pibor R.
R22 Gilo2 Dam
Gilo2 Dam Flow
Gilo R.
C48
Gilo R.
R21 Gilo1 Dam
S27
Gilo1 Dam Flow
C49
S28
D36: Gilo2 Left Bank Demand Area 11
Incremental flow from Gilo1 to Gilo2 Dam
D34: Gilo1 Left Bank Demand Areas 12
Pibor R.
Akobo R.
S30
S29
Akobo Flow
Pibor Flow


C82
Rosetta Branch
D51: Middle Delta Command Area
C82
D52: West Delta Command Area
Damietta Branch
D50: East Delta Command Area
C89
Nile at El Akhsas
B6
B5
B4
Cairo
C81
Nile at Baladeia
D49: Middle Egypt Command Area
Ibrahima Canal
C80
Nile at Hawatka DS Assuit Barrage
B3
Assiut Barrage
C79
Nile US Assiut Barrage
C76
Nile DS Nag Hammadi Barrage
Nag Hammadi Barrage
B2
B1
Esna Barrage
C77
Dagash
D48: Upper Egypt Command Area
C76
Gaafra
C76
R31
Aswan
D47: Tushka Irrigation Demand
C75
DS Aswan
R30
HAD
C74
US Aswan
R29
Dal
R28
Kajbar
C73
Dongola
D46: Hasanab-Dongola Irrig. Demand
R27
Merowe
R25
Shereig
Incremental Flow Girba D
S18
C72
Atbara Junction
Atbara Kilo 3
C38
Atbara River
Hassanab
C71
D45: Tamaniat-Hassanab- Irrig. Demand
R24
Sabaloka
Tamaniat
C70
D44: Khartoum-Tamaniat- Irrig. Demand
Main Nile
C63
BN-WN Junction