Nile Basin Initiative

Eastern Nile Subsidiary Action Program (ENSAP)

Final Report

Eastern Nile Irrigation and Drainage Studies

Cooperative Regional Assessment

Analysis Report

May 2009

MCE

BRL Ingénierie

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Fiscal Year:

Egypt: 01 July – 30 June

Ethiopia: 08 July – 07 July

Sudan: calendar year

Abbreviations

m	=	metre
km	=	kilometre
Ha	=	hectare
km^2	=	square kilometre
m^3	=	cubic metre
Mm^3	=	million cubic metres
BCM	=	billion cubic metres

Currency Unit: Dollar of the United States of America (USD).

1.00 UA	=	1.35952 USD.
1.00 USD	=	9.8 Ethiopian Birr (ETB), May 2008.
1.00 USD	=	2.0 Sudanese Pound (SDG), May 2008.
0.42 Ha	=	1.00 feddan.

Conversion factors

1 kantar	=	143 Kg.
1 ton	=	7 Kantar.
1 Ha	=	2.38 feddan
1 feddan	=	0.42 hectare

List of acronyms

BCEOM	Bureau de Conseil et d'Etude Outre Mer (French consulting firm)
BCM	Billion Cubic Meters = 1 km^3
CoSAER	Commission of Sustainable Agriculture and Environment Rehabilitation (Ethiopia)
ENTRO	Eastern Nile Technical Regional Office
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENCOM	Eastern Nile Council of Ministers
EPRDF	Ethiopian People Revolutionary Democratic Front
FAO	Food and Agriculture Organization
IMT	Irrigation Management Transfer
IPTRID	International Programme for Technology and Research in Irrigation & Drainage
IWC	Irrigation Water Corporation (Sudan)
IWMI	International Water Management Institute
masl	Meters above sea level
MoIWR	Ministry of Irrigation and Water Resources (Egypt or Sudan)
MoWR	Ministry of Water Resources (Ethiopia)
NBI	Nile Basin Initiative
O&M	Operation and Maintenance
PPPP	People Public Private Partnerships
PIM	Participatory Irrigation Management
SAP	Subsidiary Action Programmes
SPLA	Sudanese People Liberation Army
TOR	Terms of Reference
SVP	Shared Vision Programme (of the Nile Basin initiative)
USBR	United States Bureau of Reclamation
WB	World Bank
WUA	Water Users Association

1. Introduction

1.1 The Eastern Nile Irrigation and Drainage Study

The Nile Basin Initiative (NBI) was established in 1999 by the ten Nile riparian states[1] as a cooperative programme to address poverty, environmental degradation and instability in the Nile Basin while promoting socio-economic development. In order to transform their vision into action, the Nile Riparian countries developed a Strategic Action Programme which is being implemented through two complementary programmes:

- The Shared Vision Programme (The SVP) which is intended to build trust among the states, to improved implementation capacity and lay the ground for cooperative investment and development; and
- The Subsidiary Action Programme (The SAP) which is oriented towards investment projects at the sub-basin level while involving all potentially affected states

Two sub-basin programmes have already been initiated under the SAP covering respectively the Eastern Nile and the Nile Equatorial Lakes Regions. The Eastern Nile Subsidiary Action Programme (ENSAP) covers Egypt, Ethiopia and Sudan under the direction of the Eastern Nile Council of Ministers of Water Affairs (ENCOM) while the Nile Equatorial Subsidiary Action Programme (NELSAP) covers Burundi, the Democratic Republic of Congo, Kenya, Rwanda, Tanzania and Uganda, but also includes Egypt and Sudan since they are obvious affected stakeholders to any intervention in the NEL sub-region. The ENSAP and NELSAP share the same objective which is to develop the water resources of the Eastern Nile Basin and of the Nile Equatorial Lakes Basin respectively in a sustainable and equitable fashion so as to ensure peace, security and prosperity throughout the Nile Basin as a whole.

The Eastern Nile Irrigation and Drainage Study is part of the ENSAP and is intended to contribute to the enhancement of food security, reduction of rural poverty and reduction of population pressures in the sub-basin with all associated beneficial effects on the environment. It has two components:

- An Engineering Sub-study; and
- A Cooperative Regional Assessment Sub-study

1 Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda – but of these Eritrea currently holds only an observer position.

1.2 THE COOPERATIVE REGIONAL ASSESSMENT

The Cooperative Regional Assessment (CRA) is geared at enhancing the understanding of benefits and costs accruing to irrigation and drainage projects across the sub-basins countries. The CRA will propose guidelines for the selection of such projects having regional interest or implications and will develop a methodology to render explicit, using actual data, the incremental benefits of cooperation and the distribution of the costs and benefits of those projects. From an institutional perspective, the CRA is also intended to assess the consistency of member countries' policies for rural development, especially with respect to subsidies, tariffs, trade restrictions and incentives etc and in so doing, the CRA is also intended to identify appropriate institutional and legislative reforms for enhanced cooperation among the Eastern Nile countries for the medium and long term. It has three Phases:

Phase 1: Inception

This phase, which is now complete, was intended to produce generic guidelines for the identification and assessment of irrigation and development projects which maximise benefits at the national and regional levels.

Phase 2: Analysis

This phase comprises three sub-components:

- A ***Transboundary Analysis*** which examined, on an integrated, basin wide basis, the challenges and opportunities associated with irrigation and development;
- A ***Distributive Analysis*** which intended to i) analyse the distribution of costs and benefits likely to accrue to alternative irrigation and drainage scenarios, and ii) produce a suite of irrigation and drainage development scenarios; and
- An ***Institutional Analysis***[2] intended to identify and examine the institutional implications of equitable, sustainable irrigation and drainage development in the Eastern Nile. This in turn is intended to reveal the institutional strengthening implications for current and future cooperative management of the Nile Basin.

The logical linkage between the three Phase 2 sub-components is suggested by figure 1[3].

Phase 3: Finalisation & Conclusion

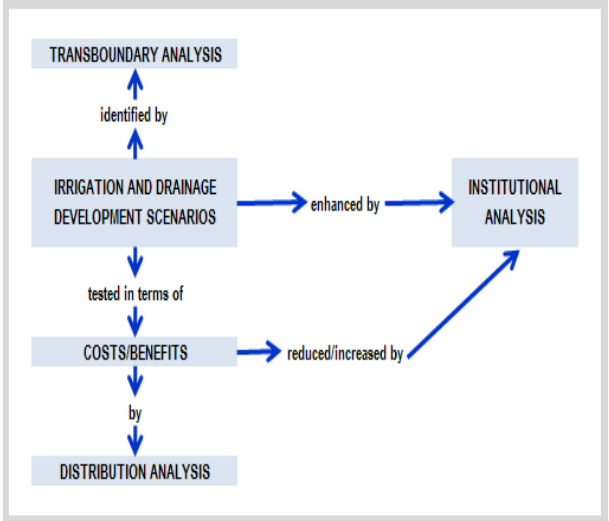
This phase is intended to identify any needs for institutional and legislative reform based on the consistency of respective Governments' policies for rural development, subsidies, tariffs, trade restrictions between countries, incentive etc. This will allow an assessment to be made of the need for regional capacity building and the crafting of a possible long-term cooperation framework for the Eastern Nile countries for the identification of regional opportunities in terms of:

- Irrigation and drainage
- Monitoring and evaluation of irrigation and drainage projects
- Promotion of funding for activities related to extension at the regional level, and
- Generalisation of locally adapted technology packages at the sub-basin level, training of farmers and field staff in on-farm-water-management through exchanges among countries, and Establishment of institutional mechanisms to ease access to credit and rural finance for projects with potential benefits at the regional level.

2 Also referred to as the Cooperative Mechanism Analysis

3 As suggested by comment 7 at the Inception Workshop

Figure 1: Logical Linkage Between Sub-Components



This analysis is concerned with the 3rd sub-component of Phase 2. It has examined in detail:

The *Levels of Cooperation* that will be necessary to achieve integrated rural development in the Eastern Nile[4]; and

The *Processes for Cooperation* that could strengthen the participating institutions, without imposing undue costs or delays

It was carried out[5] on the assumption that the overall objectives of regional cooperation are as follows[6]:

- Greater productivity and sustainability of irrigation development;
- Synergies and economies of scale as a result of regional cooperation;

and more generally:

- Enhanced cooperation and conflict avoidance amongst the Eastern Nile countries.

The present Transboundary Analysis report has two parts. The fist part gives a general picture of existing irrigation development in the Eastern Nile countries. The second part is a presentation of proposed irrigation and drainage development scenarios and analyses the related challenges and opportunities based on lessons learnt of past development in the Eastern Nile countries and other developing regions. Challenges and opportunities are classified under the essential elements of irrigation development and management: hydrology, policies, institutions and technology.

4 For instance, would the coordination of information be sufficient, or is active planning collaboration or even joint investments necessary?

5 It should be noted that in this context, institutions refer both to:
- "hard" institutions hard institutions which include public sector institutions in the form of relevant official stakeholders at every level of the civil administrative hierarchy, plus where water is managed on a basin basis, at every level of the hydrocracy. They will also include farmer organisations and private sector service providers and investors in service infrastructure.

and
- "soft" institutions which are the policies, laws, regulations and incentives that ensure the smooth and equitable running of the sector attract new players into it and guarantee the sustainability of the natural resource base on which it depends.

6 ENIDS Inception Report, page 29 refers

1.3 STRUCTURE OF THIS REPORT

The report has five parts. The first part is a synthesis presentation of existing irrigation development in the Eastern Nile basin. It provides background information on the technical characteristics of irrigation and drainage systems in Egypt, Ethiopia & Sudan, the irrigation management practices and an analysis of the performance of irrigation.

The second part "Transboundary analysis" analyses the challenges and opportunities of irrigation development in the Eastern Nile basin in terms of hydrology (availability and reliability of water supply), policies governing irrigation investments, institutions to ensure long term productivity and sustainability of irrigation schemes and technologies. The transboundary analysis also looks at how enhanced cooperation between Eastern Nile countries can profit to the three Eastern Nile countries.

The third part "Institutional Analysis" describes the institutional challenges associated with irrigation and drainage in the Eastern Nile basin and makes recommendations on levels and processes of cooperation based on an analysis of existing current agreements and experiences of other river basins in Africa and beyond.

Finally two projects profiles of joint (transboundary) irrigation projects are introduced as they were found particularly relevant to address the challenges analyzed in the Transboundary Analysis and to start implementing some of the levels and processes of regional cooperation recommended by the Institutional Analysis.

This report is supported by the following appendices:

1) Characteristics of hydropower dam projects in the Abbay basin
2) Note on the World Bank Strategy for reengaging in agricultural water management
3) Existing institutional arrangements in the riparian water sector
4) List of international river basins associations established between 1815 and 2002
5) Principles for the distributive analysis for transboundary irrigation projects
6) Institutional issues and opportunities associated with transboundary irrigation development.

2. Part I: Existing irrigation development in Eastern Nile Basin

2.1 TYPOLOGY OF IRRIGATION DEVELOPMENT

There are approx 5.3 million ha of land under irrigation in the Eastern Nile basin. FAO worldwide classification distinguishes three main categories of irrigation development: (1) full or partial control irrigation, (2) equipped lowlands and (3) spate irrigation. This study focus on irrigation schemes with full or partial control irrigation which account for the totality of irrigated area in the Eastern Nile if we except spate irrigation which covers only 80,000 ha in Sudan along the main Nile, in the Gash Delta near the town of Kassala and the Tokar delta on the Red Sea cost. In the Basin, irrigation systems differ according to their period of development, irrigation technology, total size and farm size of beneficiaries, cropping patterns, level of inputs use and farm machinery, land tenure rights, organization for operation and maintenance and so on. On one hand it is impossible to take account of each and every irrigation system on the other hand it is irrelevant to consider irrigation development as homogeneous.

We adopted a simple typology based on size and management of irrigation systems we think relevant to draw a general picture of irrigation development in the Eastern Nile basin. This typology distinguishes two main types of irrigation system:

- Centrally managed large scale irrigation systems with smallholder farmers covering 3.3 million ha in Egypt and 1.8 million ha in Sudan; and
- Farmer managed small scale irrigation systems covering approx 100,000 ha in the Nile basin in Ethiopia.

In the three countries, there also exist irrigated estates managed by public or private enterprises. In Egypt they consist of private commercial farms established in the reclaimed desert lands. In Ethiopia they comprise irrigated state farms covering a total area of approx 60,000 ha of which 75% is located in the Awash basin. The only scheme of this kind in the Nile basin is Finchaa sugar estate (8,500 ha). In Sudan irrigated estates are represented by public sugar estates managed: Kenana (36,000 ha) and New Halfa (17,200 ha). There are also relatively small pump schemes on the Blue Nile, White Nile and Main Nile managed by private owners or cooperatives. Given their relatively small importance, public or private estates were excluded of this general picture of irrigation development.

Table 1: Typology of irrigation in the Eastern Nile basin (areas in thousands of ha)

Country	PLS	SSI	Others	Total
Egypt	3,300	-	marginal	3,300
Ethiopia	-	100 (estimate)	8.5 (Finchaa)	109
Sudan	1,800	-	100 (estimate)	1,900
Total	5,100	84	108	5,309

PLS: Public large scale irrigation schemes with smallholder farmers.

SSI: Small scale irrigation managed by farmer's organizations

Others: Public or private irrigated estates

2.1.1 Public large scale irrigation systems with smallholder farmers in Egypt and Sudan

Irrigation has a history of nearly 7,000 years in Egypt and one can say that the state has always been managing the Nile waters and irrigation in a highly centralised manner since the pharaohs' era to date. Since the mid-18th century, new practices and technologies have gradually been implemented on a wider scale. The last major attempt to harness the Nile flows for productive use was the construction of the Aswan High Dam completed in 1970. In Sudan, large scale irrigation development started in the 1920's with the construction of Sennar dam and the Gezira irrigation scheme for cotton "export" to Britain the then colonial ruler. The completion of the Jebel Awlia dam (1937) on the White Nile approx 20 Km upstream of Khartoum led to the rapid development of pumping schemes.

However, in both countries the current public large scale irrigation systems have been shaped by the policies that were implemented since the 1950's. Although they largely differ in terms of outcomes, the objectives of policies implemented in Egypt and Sudan were very similar. Two periods of development can be distinguished: (1) the period 1950-1990 of government-led horizontal and vertical expansion of irrigation and (2) the period of economic liberalization from 1990 to date.

Irrigation expansion period (1950 – 1990):

Policies of Egypt and Sudan combined massive irrigation investments (including the construction of the Aswan dam), promotion of Green Revolution technology packages (selected seeds, fertilizers and pesticides) and accompanying measures aiming at facilitating farmers' adoption of these technologies. In addition Egypt went through two successive agrarian reforms in 1952 and 1961 that expropriated the large estates in various ways and redistributed the land to smallholder farmers.

These policies were strongly sustained by the Nile Water Agreement that Egypt and Sudan signed on 8th November 1959. According to the Agreement, out of the average annual flow of the Nile at Aswan of 84 BCM, Egypt has an annual guarantee of 55.5 BCM and Sudan 18.5 BCM. The remaining 10 BCM are the estimated water losses through evaporation in the reservoir of the High Aswan dam. The 1959 Agreement made possible the immediate construction of the High Aswan Dam (1962-1970), the construction of the Roseires dam (1961 – 1966) on the Blue Nile in Sudan, the Managil extension of the Gezira irrigation scheme. The Construction of the Aswan dam also led to the construction of Khashm El Girba dam and the New Halfa irrigation scheme (180,000 ha) located on the upper Atbara River in Eastern Sudan where the inhabitants of the Sudanese Nubia were resettled after the inundation of their land. In Egypt, the completion of Aswan dam provided over-years storage and flood control, which supplied agriculture with steady and until recently plentiful irrigation water. Thus the High Aswan dam offered the possibility of irrigation expansion and substantial rise in the productivity of irrigated agriculture in Egypt and Sudan.

The liberalization period: 1990 – to date:

Since the 1990's new irrigation policies aiming at liberalization of the economy and reduction of government support to the irrigation sector were designed in Egypt and Sudan. Main characteristics of Egypt and Sudan policies in the liberalization period are:

- Continuation of irrigation expansion: Reclaiming desert lands in Egypt and in Sudan, use of the country full share of the Nile waters.
- Irrigation management transfer to farmers' organizations
- Removal of government control on crop prices, cropped areas and cropping patterns
- Removal of subsidies on farm inputs
- Promotion of private sector involvement in irrigation development and management
- Liberalization of the land market in Egypt

Implementation of these policies started too recently to have produced significant change in the overall picture of irrigation in Egypt and Sudan. This first part of the report gives an overall picture of irrigation development in Egypt and Sudan as it has been shaped by the policies implemented between 1950 and 1990.

2.1.2 Farmers-managed small scale irrigation in Ethiopia

Rural communities living nearby water sources have been developing small-scale irrigation for decades and sometimes centuries with minimal or no support from external bodies like the government or NGOs. Most of these so called « traditional irrigation schemes » are river diversions. Spring development and hand dug wells are also other sources of water for traditional irrigation. Irrigation management is usually organized by community-based irrigation committees run by elected leaders, the "Water Fathers". There is no systematic record of the traditional schemes. However the estimated total development of traditional irrigation is assumed to be about 200,000 ha and it represents almost 60% of the total irrigated area of about 340,000 ha in the country. In the Nile basin total area of traditional irrigation is estimated at about 60,000 ha.

It's only after the devastating drought of 1984/85 that the Derg Regime decided the establishment within the Ministry of Agriculture of a department for the development of small scale irrigation: The Irrigation Development Department (IDD). However, activities of the IDD were limited to the construction of over thirty small scale irrigation schemes with no specific accompanying measures to guarantee their viability. The EPRDF government came to power in 1991 and, despite very little support from donor agencies, put an emphasis on small scale irrigation development under the mandate of regional institutions such as Commissions of Sustainable Agriculture and Environment Rehabilitation (CoSAER) or Irrigation Development Authorities, these institutions were recently dismantled. Most of modern small scale irrigation schemes (MSSI) are river diversion but they also involve micro dams or pumping. Sizes of MSSI range between 10s of hectares and 3,000 ha[7]. They are organized by recently government-introduced irrigation cooperatives. The total command area under MSSI is approx 80,000 ha of which 30% or about 24,000 ha is located in the Nile basin. More recently, micro irrigation systems using rainwater harvesting storage structures have been developed through large government programs. The small size of storage structures limits their utilization to supplementary irrigation of rain-fed crops.

Past irrigation development in Ethiopia was impeded by lack of financial capacity and a set of constraints related to policy, institutions, technology, human capacity, rural infrastructures and markets. The current strategy in the irrigation sector consists in the expansion of irrigated area for increasing food security, eradicating poverty and related social and environment conservation objectives by developing the almost untapped huge water resources of the country such as the Blue Nile. According to the irrigation policy, irrigation systems will be managed by Water Users Associations (WUAs) or, for the larger schemes, jointly managed by WUAs and public or private irrigation agencies. Contrary to Egypt and Sudan, Ethiopia has no experience of large-scale irrigation schemes with smallholder farmers. The first large scheme with smallholders (Koga - 6,000 ha) is currently under construction. In short, Ethiopia is now entering an era of construction of dams, reservoirs and canal distribution networks; it also wants to address the entire set of constraints of irrigation development to ensure productivity and long term sustainability of irrigation.

[7] The official classification of the MoWR distinguishes small scale irrigation as less than 200 ha and medium scale irrigation as 200 to 3,000 ha. Given the size of systems in Egypt and Sudan, we have considered irrigation schemes below 3,000 ha as 'small scale' irrigation schemes.

2.2 CHARACTERISTICS OF IRRIGATION DEVELOPMENT IN EGYPT.

2.2.1 Irrigated area and water use for irrigation

In Egypt, irrigated area consists in the old and new lands plus oases. The old lands are located in the Nile Valley and Delta Regions. They cover a total area of 2.25 million ha and are characterized by alluvial (Ethiopian) clay to loamy soils deposited by the Nile over thousands of years and until the construction of High Aswan dam. The new lands are reclaimed desert land located on both the east and west sides of the Delta and scattered over various areas in Upper Egypt (South of Cairo). Reclamation of desert land started in the 1950's, accelerated after the completion of the High Aswan dam and is continuing. At present, new lands cover approx 1.1 million ha. Hence, the total irrigated area is at present 3.35 million ha plus 40,000 ha of oases. Annual cropped area is approx 6.1 million ha and cropping intensity is 180%. The Nile is the source of irrigation water; in some oases fossil underground water is used. Table 2 gives details on irrigation schemes in Egypt.

Table 2: Irrigated areas served from the Nile in Egypt.

Name of main canals	**Area x 1,000 ha**		**Name of main canals**	**Area x 1,000 ha**
Upper Egypt, Nile Valley			*Upstream Delta barrage*	
El Ibrahimiya	645		El Raiyah El Monofi	309
Naga hamadi El sharkia	43		El RaiyahEl Bihiri	502
Naga hamadi El Gharbia	179		El Raiyah Al Nasri	32
El Kalabia	72		El Raiyah Al Tawfiki	282
Asfun	29		Ismailiya canal	244
Direct intakes	174		Direct intakes	127
TOTAL UPPER EGYPT	**1,142**		*Domiatta Branch, East Delta*	
			El Raiyah El Abasi	329
			El Mansoria	136
			Direct intakes	77
			Rosetta Branch , West Delta	
			Mahmoudia (pumping)	120
			Direct intakes	45
			TOTAL DELTA	**2,204**
TOTAL UPPER EGYPT + DELTA	**3,346**			

Note: Canals are gravity fed by diversion while the numerous direct intakes involve pumping.

Water use for irrigation

Water diverted from the Nile for agriculture is approx 58 BCM of which 4.8 billions are reused drainage water and 6 BCM are renewable groundwater (seepage from the Nile). The average unit water diverted per Ha fro areas served by the Nile is 58 BCM/ 3.35 Million Ha equal to 17,300 m^3/Ha/year.

2.2.2 Irrigation and drainage technology

The irrigation system in the old lands of the Nile Valley and Delta is a combined gravity and water lifting system. Downstream of the High Aswan Dam, there are eight dams on the Nile or its Delta branches to facilitate water abstraction. The main canal system (first level) comprises 31,200 km of canals and takes its water from head regulators located upstream of the Nile barrages or pumping for the "direct intakes". The main canals are equipped with regulators (weirs) maintaining a constant upstream level. Water is distributed along branch canals (marwas) where the flow is continuous. At the third level, field distributaries (meskas) receive water according to a rotation schedule. Water is pumped from the distributaries to irrigate fields (lift between 0.5 and 1.5 m). Field water application involves either small basins or furrows for row crops.

The irrigation system in the new lands (reclaimed desert land) is based on a cascade of pumping stations from the main canals to the fields, with a total lift of up to 50 m. Surface irrigation is banned by law in the reclaimed areas which are located at the end of the systems and are more at risk of water shortage. Farmers must use sprinkler or drip irrigation which are also more suitable for the sandy soils of those areas.

An extensive National Drainage Programme has been carried out over the last four decades to control water logging and salinity. The drainage system consists of open drains, sub-surface drains and pumping stations. Currently almost all the irrigated area is drained, of which about 2.2 million ha with sub-surface piped drainage system. There are 99 pumping stations devoted to the pumping of drainage effluent. Drainage water from agricultural areas is returned to the Nile or main irrigation canals in Upper Egypt and in the Southern Delta. Drainage water in the Northern Delta is either pumped to irrigation canals or into the northern lakes or the Mediterranean Sea. Salinity and water logging are now under control in about 80 % of the irrigated lands. Water logging and salt affected areas reduced from 1.2 million ha in 1970 to 250,000 ha at present. Total reuse of drainage water for irrigation amounts to 4.8 BCM per year. In addition, approx 6 BCM of renewable ground water (seepage from the Nile) is pumped annually for irrigation. Salinity remains a problem in the Northern part of the Delta where no ground water is pumped.

2.2.3 The Irrigation Improvement Program

The government of Egypt is committed to a long term ***"Irrigation improvement Program"*** which will continue for the next 15 years. The aim of the program is water saving to facilitate horizontal irrigation expansion by reclaiming desert land. The objective of the program is to increase water use efficiency at farm level. To achieve its objective the program undertakes in an integrated manner the introduction of raised and sometimes lined field canals (meskas) or pipelines involving farmers' participation in cash and labour, continuous flow in meskas, and single pump lifting from branch canals (marwas) managed by Water Users Associations. The program is the up-scaling at national level of the former Irrigation Improvement Project (IIP), which was supported by the United States Agency for international development (USAID). The IIP was implemented over the period 1981 – 1998; it undertook exactly the same activities on selected pilot sites.

The Irrigation Improvement Program is potentially revolutionary in its impact because it wants to establish legally recognized Water Users Associations and cost sharing mechanisms related to investment costs. Through improved water control at field canals level, it is very likely to increase on-farm productivity and farmers' incomes; i.e. surveys in pilot sites of the IIP showed that increases in net farm profits was between 30% and 50%. But as the IIP, the program is facing unresolved issues. These include shifting of the whole system to continuous flow at mesqua level, the long-term role and responsibilities of Water Users Associations and their relationships with the Ministry of Water Resources and Irrigation, the cost effectiveness of the technology package and whether increasing on-farm irrigation efficiency can actually save water at basin level.

The cost of establishing a pumping station and a lined meska or pipe serving 65 ha in average is around 260,000 Egyptian Pounds (= 48,000 USD) according to Kafr Al Sheikh Directorate irrigation engineers. The expected impact - water savings at basin level - is dubious if not illusory because in most part of Egypt irrigation system, water "lost" at farm level returns to the Nile or main canals through the drainage system and is reused.

A major conclusion of Egypt "Water Master Plan" (1985) was that because of the large amount of reuse of water occurring in the Nile Basin, the system as 'a closed basin' is actually more efficient than usually assumed. Thus, the potential for saving water to support expansion of the irrigated area is less than planners had believed. This finding seems to have been ignored.

2.2.4 Land tenure

In Egypt two successive agrarian reforms in 1952 and 1961 expropriated the large private estates and redistributed the land to farmers. Farm size is limited by law to 50 feddans (21 ha) for an individual and 100 feddans (42 ha) for a family but farms of this size are not common in Egypt. The average farm size of the approx 5 million Egyptian farming households is 1.5 feddan (0.63 ha) and 80% of holdings do not exceed 3 feddans (1.26 ha).

The general system is one of individual land tenure. Transfers of titles take place through inheritance and the market. The operative farm unit is the holding, defined currently as: land owned plus land legally "rented in" minus land legally "rented out". Most often, the land that is "rented in" occupies between one-third and one-half of the holding. The official annual rent was about LE 2,000 per feddan (370 USD) in the year 2005; there was substantial higher unofficial rate reflecting free market conditions.

Egypt tenant farmers are now struggling to come to terms with the recent land tenancy reform. After a five years "grace period", tenant farmers became subject to a 1992 law allowing landowners to charge market level rents and denying tenants the right to pass rented land on to their children.

2.2.5 Irrigated Agricultural production

The totality of the 3.3 million ha agricultural lands is irrigated; with a cropping intensity of 180%, the total annual cultivated area is 6 million ha. Increase of cropping intensity was made possible through improved water management and cultivation of early maturing varieties and above all the completion of the Aswan dam.

Cropping pattern

The agricultural production can be divided in five categories: (1) cereals, (2) Fodder, (3) pulses, (4) industrial crops and (5) horticultural crops. Cropping patterns in the Delta and Upper Egypt are identical with the exception of sugar cane grown in Upper Egypt only and rice cultivated in the Delta only. Rice cultivation in the Delta is seen as one of the means to control salinity and is perhaps the last opportunity to use water before it flows to the sea. See figures 1 and 2 show cropping patterns in 2002.

Cereals occupy 2.7 million ha, 45% of the cultivated area. Main cereals are wheat (1 million ha), rice (650,000 ha) and maize (800,000 ha). Other cereals grown in Egypt are sorghum (160,000 ha) and barley (90,000 ha).

Fodders are grown on 1.2 million ha. Berseem (*Trifolium alexandrinum*) is the main forage crop and occupies (1.1 million ha). Berseem is grown either over 3 months with 2 cuts as a soil improver (short berseem) usually preceding cotton, or over 6-7 months, either with 4-5 cuts as a fodder crop or grazed by tethered cattle (long berseem). Alfalfa occupies 100,000 ha.

Pulses are grown of 160,000 ha; they include beans, lentils and chickpeas.

Industrial crops are grown on 640,000 ha. They include cotton (300,000 ha) the main Egyptian crop for export, sugar cane (135 000 ha), sugar beet (65,000 ha) and oil crops (soybeans 26,000 ha, sunflower 15,000 ha, sesame (30 000 ha) and groundnut (60,000 ha).

Horticultural crops are grown on approx 1.3 million ha. They include potatoes (82,000 ha), vegetables (600,000 ha). Fruit trees, mainly citrus and bananas, occupy 600,000 ha. Medicinal plants, flowers and spices are a small but rapidly growing farm business. Horticultural products are sold for the domestic markets and provide some surplus for export.

Figure 2: Annual cultivated area by type of crops in Egypt (total cultivated area: 6 millions ha)

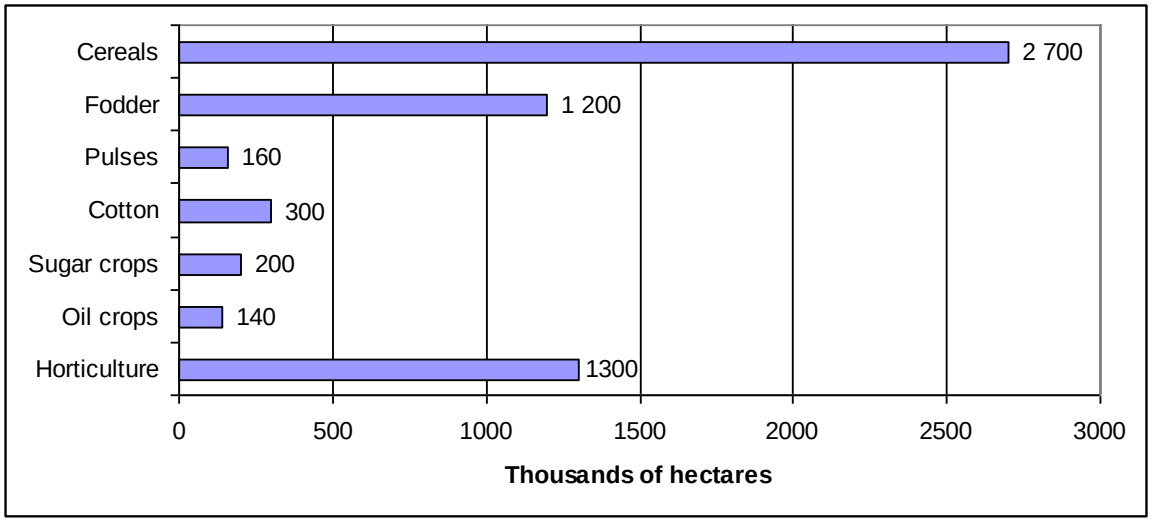
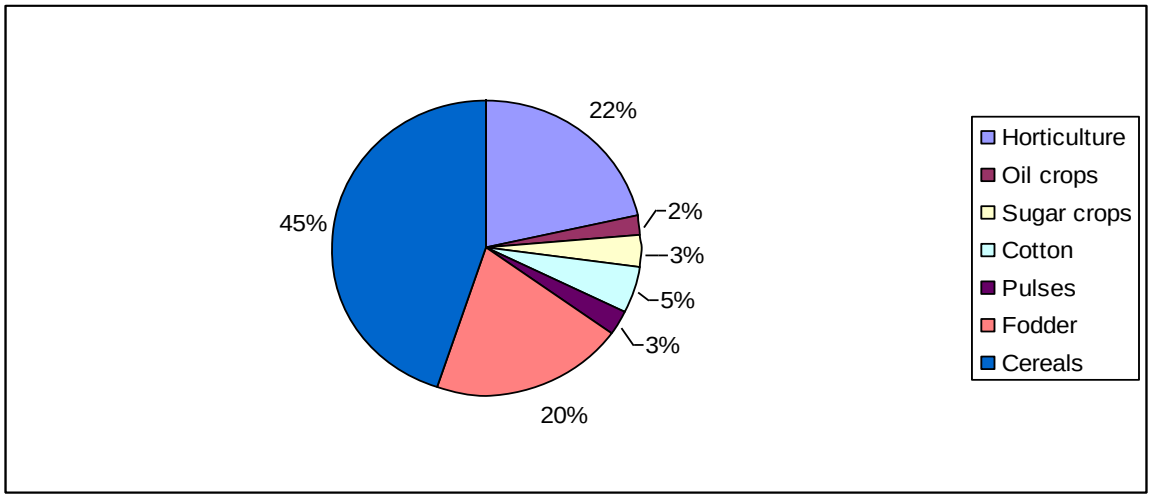


Figure 3: Cultivated area by type of crops in percentage of total cultivated area in Egypt



Crop rotation

There are three growing seasons in Egypt: winter: from November to May; summer: from May to July / August; and "Nili": from July/August to October. The main winter crops are wheat and berseem. Minor winter crops are, amongst others, pulses, barley and sugar beet. The main summer crops are maize, rice and cotton.

Yields or Egypt's Green Revolution.

In the early 1960s and following the agrarian reforms, the government of Egypt regulated the cultivated area and production of many crops including cotton, wheat, rice and sugar cane. In addition, farmers were obliged to deliver all or part of their production to the government at prices which were lower than the free market prices. The government handled marketing and processing through socialist cooperatives.

These measures were a part of the general context of the National Economic Plan, i.e. the agricultural sector was interrelated with other sectors of the economy. For example, a shortage in the supply of cotton would lead to losses in the industrial sector. Extension services specified the quantity of seeds, fertilizers and pesticides to be supplied to farmers for each season. The Principal Bank for Development and Agricultural Credit (PBDAC) provided all agricultural inputs at subsidized prices. Overall performance of the agricultural sector remained relatively low at the end of this period.

In 1980, major reforms were introduced in the framework of the agricultural sector strategy for the 1980s. The reform program combined promotion of technology packages (selected seeds, fertilizers and pesticides) through massive extension campaigns such as two national campaigns for wheat and for rice improvement and accompanying measures such as price incentives for wheat growers, quotas of production with guaranteed market prices and outlets, protections against imports of low price agricultural commodities and inputs subsidies through the PBDAC. The results were a considerable increase of production and yields as illustrated in table 3.

Table 3: Comparison of yields of selected crops in the early 80's and today in Egypt

Crops	Average yields in the early 80's (ton/ha)	Average yields today (ton/ha)
Wheat	2.0	6.4
Maize	4.0	8.1
Rice	3.5	9.4
Cotton	1.0	2.6
Sugar cane	85.0	120.0

Source: FAO 2002 and data compiled by the consultant.

The above clearly shows that Egypt accomplished its Green Revolution in two stages: land redistribution and strong control over farmers (1960 – 1980) then dissemination of technology packages (1980 – 1993). By 1993 the agricultural sector was liberalized:

- Governmental control of commodities prices and production quotas were removed;
- Governmental control as regards the import and export of agricultural commodities was removed;
- Subsidies on farm inputs were eliminated and the role of PBDAC was diverted to the provision of financial services;
- "New lands" were sold by the government to the private sector;
- The land tenancy system was modified.

So far impact the main impact of these reforms, especially those involving the removal of governmental controls on production and prices, was a change in the cropping pattern to the profit of high value crops (i.e. horticultural crops) and at the expense of less profitable crops such as cereals.

2.2.6 Irrigation management and cost recovery

The Ministry of Water Resources and Irrigation (MWRI) undertakes the construction, operation and maintenance of the irrigation and drainage networks. Specifications and permits for groundwater well drilling are also the responsibility of MWRI. Further to the above institutions, other public authorities are directly related to MWRI:

- The High Dam Authority is responsible for Aswan dam operation.
- The Drainage Authority is responsible for the construction and maintenance of the drainage system.

Features of the "Irrigation Improvement Program" show the MWRI wants to shift emphasis from its role as the central (and sole) actor in developing and managing irrigation towards promoting participatory approaches in which water users will play an active role in the management of irrigation systems and will share the cost of construction, operation and management of irrigation systems at least at the field canals level. However, there is a highly centralised decision making in the MWRI and accountability of its staff is directed upward and not toward farmers. Little authority is located at the lower levels, which may be the most relevant for participatory formation and empowerment of Water Users Associations.

Water Users' Associations (WUAs) as effective partners in irrigation management remain at an infant stage but most farmers recognize the benefits of WUAs in terms of reliability and equity of water distribution. Uneven water distribution is either due to design shortcomings or individualist responses by farmers to the present highly centralised water supply management.

At present, irrigation water is free for Egyptian farmers except for the costs of pumping water into their fields. The MWRI does not intend establishing any irrigation water pricing system.

2.3 CHARACTERISTICS OF IRRIGATION DEVELOPMENT IN SUDAN

2.3.1 Irrigated area and water use for irrigation

The 1970's were a period of rapid irrigation expansion in Sudan based on the construction of large pump fed irrigation schemes: El Ski (37,800 ha), Rahad I (126,000 ha), Kenana sugar estate (37,700 ha), North-West Sennar sugar scheme (13,900 ha), Assalaya sugar scheme (14,700 ha) and a number of smaller schemes along the Blue, White and main Niles. Almost al these schemes were modelled on the Gezira scheme for their design and style of management. Area of public irrigation schemes also expanded in the early 1970's when the government bought from private owners 439 schemes on the White Nile, 314 on the Blue Nile and 100 downstream Khartoum. Most of these pumping schemes were then in bad condition and the scheme owners welcomed the government initiative.

In Sudan, irrigated area expanded from 1 million ha in 1956 to 1.9 million ha by the end of the 1970's. Tables 4 give details of current irrigated area in Sudan. Storage capacity of Sudanese dams and Sudan share of the Nile waters limit cropping intensity to 100%. In practice average cropping intensity in Sudan does not exceed 50 to 60%. Since the end of the 1970's, no major irrigation development took place. Priority irrigation development projects are Upper Atbara dam and irrigation project (117,600 ha); Rahad phase II (210,000 ha) and Great Kenana project (420,000 ha) on the Blue Nile. Construction work for heightening Roseires dam by 10 m has recently started for securing water supply to the future Blue Nile projects. The total projects area amounts to almost 1.2 million ha. These projects are further described in chapter 3.3 on irrigation scenarios.

Table 4: Irrigation schemes in Sudan

Name of scheme	Area (x 1,000 ha)	Water source	Remarks
Gezira and Managil	924	Blue Nile	PLS
Rahad I	126	Blue Nile	PLS
Suki	36	Blue Nile	PLS
North West Sennar (Sugar)	14	Blue Nile	PLS
Guneid	36	Blue Nile	PLS
Abu Nama (jute)	13	Blue Nile	PLS
Blue Nile Pump schemes	153	Blue Nile	PLS + SPS
Assalaya (Sugar)	15	White Nile	PLS
Kenana Sugar Estate	36	White Nile	Public estate
White Nile Pump Schemes	197	White Nile	PLS + SPS
Main Nile Pump Schemes	88	Main Nile	PLS + SPS
New Halfa	180	Atbara	PLS
TOTAL	**1,817**		

PLS: Public large scale schemes with smallholder farmers. SPS: Small private scheme owned by private owners or cooperatives.

Water withdrawal for irrigation in the Nile basin in Sudan is estimated at 15 BCM. Assuming an average cropping intensity of 60%, average water consumption per cultivated unit of cultivated land is 13,400 m^3/ha.

2.3.2 Irrigation and drainage technology

All the schemes involve pumping from the water source except the three largest schemes. The Gezira scheme is gravity-fed while in Rahad I and New Halfa schemes pumping is supplemented by gravity water supply. The White Nile schemes are located upstream of the Jebel Awlia dam which regulates water level. Blue Nile schemes benefit of regulated waters of Roseires and Sennar dams. For the Main Nile schemes, water is (partially) regulated by Jebel Awlia dam and the Blue Nile dams. New Halfa scheme intake is regulated by the Khashm El Girba dam on the Atbara River.

In most schemes water distribution system includes four levels: main canal, major canals, minor canals and field canals locally known as Abu Ishrin (Abu 20). Gravity flow is continuous in all canals and farmers practice night irrigation although minor canals are often designed for storing night water. Field application method is basin irrigation; farms are divided into small basin units that are irrigated until there is free standing of water throughout the field. Irrigation efficiency is poor and with impeded drainage of Sudan vertisols, excess water cannot be evacuated. Attempts to introducing furrow irrigation in the Gezira and Rahad I irrigation schemes have failed.

The control structures are designed to maintain a constant upstream level and the discharge is controlled by manually operated means. Sluice gates or movable weirs are used at the intakes of major and minor canals. Intermediate weirs are used in the minor canals allowing night storage and controlling the flow of intakes (gated pipes) of the field canals.

The drainage system consists of open drains. Minor drains run parallel to minor canals. They discharge into the major or collector drains, which follow the lines of natural drainage until the nearest River. In some cases major drains terminate in large local depressions where water accumulates and then evaporate. In the heavy clay soils (vertisols or black cotton soils) the drainage systems can only evacuate excess rain water.

2.3.3 Rehabilitations

By the end of the 1970's and despite unsatisfactory productivity of irrigated agriculture, the agenda of the ministry of Irrigation and Water Resources was to start the construction of Rahad phase 2 and Upper Atbara dam and irrigation projects. Most of all, the Ministry wanted to raise the crest of the Roseires dam, whose reservoir, like the one at Khashm El Girba on the Atbara River, was rapidly silting. This plan was sustained by ***"The Nile Waters Study"*** (1978) undertaken by the consulting firm Coyne and Bellier. The World Bank had another opinion. It called for a halt of the construction and it advocated instead the rehabilitation of existing schemes. As the financial capacities of the Sudanese Government were limited at that time, the opinion of the Bank prevailed.

Between 1980 and 1983 the World Bank made a series of loans for rehabilitation of irrigation schemes with funds for improved irrigation infrastructures, roads and buildings. New Halfa came first in 1980 with a loan of 40 million USD. The next year the Bank made two loans of approx 30 million USD for the Blue Nile and White Nile pump schemes. In 1983, a package of 260 million USD was put together by the Bank and the governments of Saudi Arabia, Japan and the United Kingdom for rehabilitation and modernization of the Gezira irrigation scheme. In 1985, the British undertook the rehabilitation of a group of Main Nile pump schemes and in 1986 the International Fund for Agricultural Development (IFAD) lent 10 million USD for other schemes farther downstream.

Besides upgrading of infrastructures, these rehabilitation projects advocated for institutional and managerial changes such as establishment of Water Users Associations and programs for farmers recovery of operation and maintenance costs. Reluctance of the Sudanese government to guarantee that it would implement the proposed institutional reforms and top-down approach of the rehabilitation projects resulted in the fact that recommendations for institutional reforms were not implemented. A World Bank report ***"Options for sustainable development of the Gezira irrigation scheme"***, dated of October 2000, states (page 2): *"The Gezira Scheme has been studied numerous times over the last 30 years. Many of these studies were financed by bilateral and multilateral donors including the World Bank. They made recommendations for change in the institutional arrangements and management of the Gezira scheme. In many cases recommendations made 10 to 20 years ago were similar to recommendations in more recent studies. The failure to take action in the past to remedy obvious institutional problems has resulted in the current serious deterioration in all aspects of the Scheme. It is certainly time to take action."* In other words, Sudan public irrigation schemes seem to be caught in the well known vicious circle of rehabilitation / degradation due to enduring institutional and managerial difficulties.

The new liberalization or privatization policy wants to undertake major reforms, namely Irrigation Management Transfer (IMT) to farmers' organizations and promotion of the private sector. These reforms are being tested in the Gezira irrigation scheme.

2.3.4 Land tenure

In Sudan public irrigation schemes, the land belongs to the government and farmers are tenants. The tenancy system in all public irrigation schemes is modelled on the Gezira irrigation scheme whereby:

- Tenant farmers are not allowed to sell or rent their tenancy, in full or in part, except with the consent of the government;
- Tenant farmers are not allowed to own more than one tenancy;
- A tenancy can be inherited but it can be officially fragmented only in half the size of a full tenancy.

The official tenancy size is 20 feddans in Gezira Scheme, 15 feddans in Rahad I and New Halfa. This tenancy size is considered to be too small to allow mechanized agriculture and too large for efficient application of labour intensive technology.

The tenant system was designed in the 1920's, and has become increasingly unsatisfactory as a result of social and economic changes. This was well illustrated in 1987 when DELCO, an Irish consulting firm, submitted its report of a study that was commissioned as part of the preparation for the Gezira irrigation scheme modernization project. DEVCO estimated that 85% of the labour of the entire scheme was done by hired labourers, and only one third of the tenants worked full time on their tenancies. A more recent study (1998) by Raga Mohamed El-Zaki Ali[8] confirms this figure and adds that approx half of the Gezira tenant farmers enter into sharecropping practices whereby the sharecropper receives half of the product. The main reason why tenants engage in sharecropping is their inability to finance hired labour, or their involvement in off-farm activities, which prevent adequate supervision of, hired labour. Many hired labourers originate in West and Central Africa (Nigeria, Chad) and the Sudanese regions of Darfur and Kordofan.

2.3.5 Agricultural production

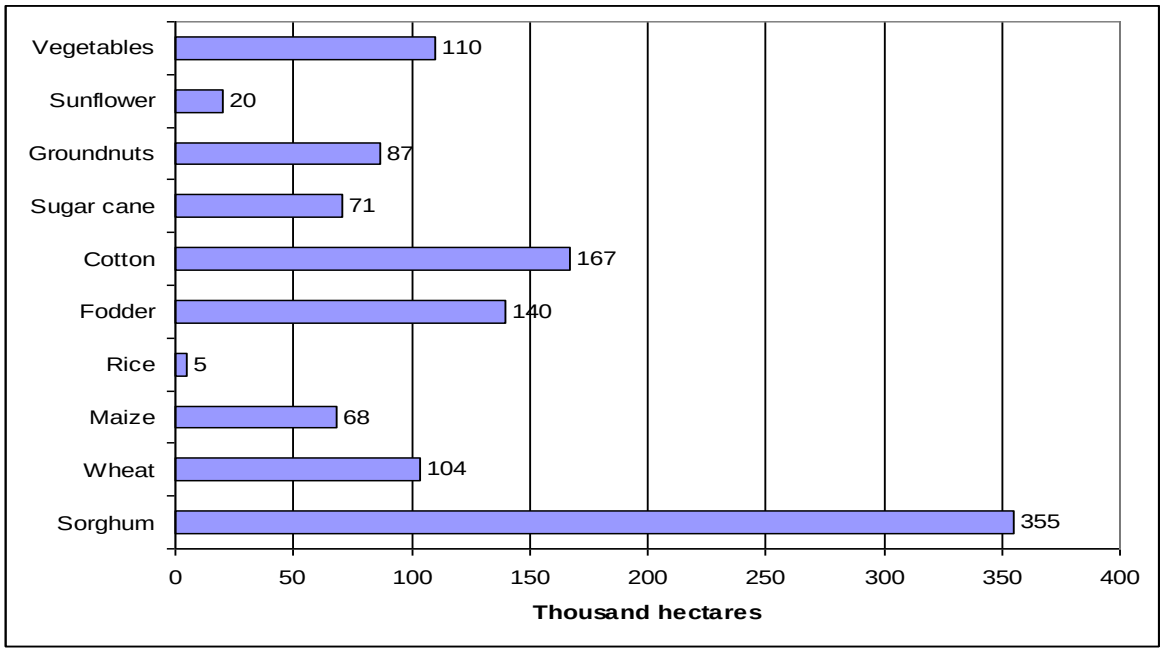
Cropping patterns and crop rotation

In Sudan the total irrigation cropped area is approx 1.1 million ha (FAO, 2000) and the cropping intensity 50 to 60%. Irrigated agriculture production can be divided into four categories of crops: (1) cereals, (2) fodder, (3) industrial crops and (4) horticultural crops. Figure 4 gives the areas cover by the various irrigated crops in 2000.

Cereal crops represent about 50% of the cropped area occupying 532,000 ha of the 1.1 million ha cropped area. Sorghum occupies 355,000 ha and is the dominant crop in Sudan irrigation schemes. Wheat occupies 104,000 ha, maize 58,000 ha and rice 5,000 ha.

Fodder crops represent 140,000 ha or 12% of the cropped area. The main fodder crop is lubia (*Dolichos lablab*), a type of bean. The relatively small area of fodder crops contrasts with the importance of livestock.

Figure 4: Irrigation cropping pattern by category of crops for Sudan

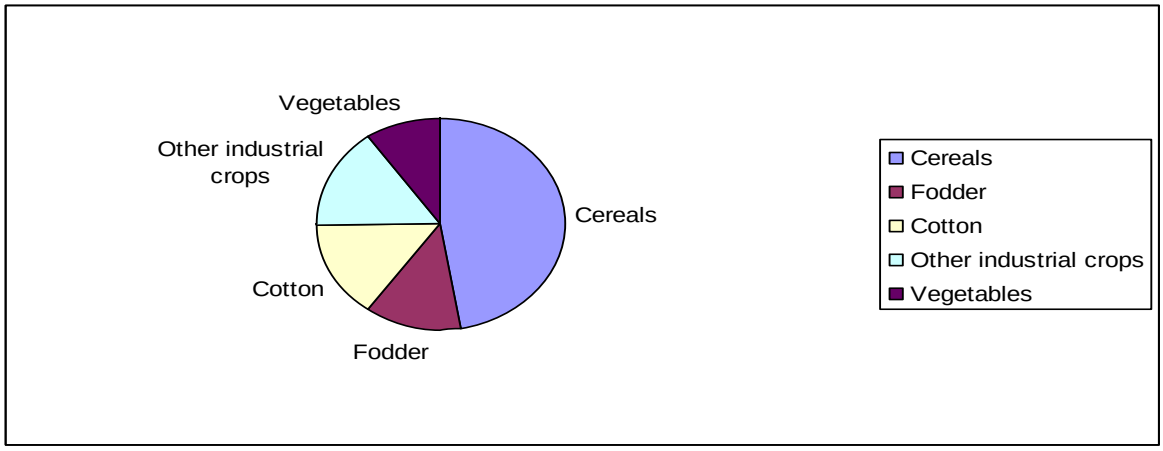


[8] THE FEASIBILITY OF INTEGRATION OF LIVESTOCK PRODUCTION IN IRRIGATED AGRICULTURE IN SUDAN
(CASE STUDY: THE GEZIRA SCHEME), 1998.

Industrial crops cover approx 345,000 ha or 30% of the total cropped area. Cotton occupies 167,000 ha and is the main source of agricultural export. Sugar cane covers 71,000 ha and oil crops, groundnut and sunflower, 87,000 ha and 20,000 ha respectively.

Horticultural crops: vegetables, occupy 110,000 ha. Vegetables are grown for the domestic market.

Figure 5: Irrigation cropping pattern in Sudan by category of crops



Source FAO (2003)

Livestock represents an important part of agricultural production in Sudanese irrigation schemes. Most tenant farmers and farm labourers own cattle and small ruminants. As an example, table 5 below gives livestock population in the Gezira irrigation scheme in 1999. Livestock owned by tenant farmers or farm labourers are fed on crop residues. Beside this, there are also systems of contract between tenant farmers and nomadic pastoralists involving exchange of manure for crop residues or fodder, and grazing of tenants' livestock with transhumance livestock herders. Cattle are not used for land preparation. Donkeys and horses are used for carrying people, crop production and other goods.

Table 5: Livestock population in the Gezira irrigation scheme (number of heads)

Cattle	Goats	Sheep	Donkeys	Horses	Camels
410,000	640,000	580,000	107,000	9,700	2,900

Source: Raga Mohamed El-Zaki Ali, University of Khartoum (1999)

At schemes level cropping patterns are prescribed by the Agricultural Corporations and have evolved over time. For example prescribed cropping patterns in the Gezira, Rahad I and New Halfa irrigation schemes are as follows:

- **Gezira:** The cultivable area is approx 900,000 ha. The Typical 20 feddan (8.4 ha) farm is divided in five "courses" of four feddans. For the period 1991/92 – 2005/06 The current five courses cropping pattern and crop rotation was as follow:
    - Cotton - Sorghum - Wheat or other winter crop – Groundnut – Fallow
    - Since a law passed in 2005, farmers are given free choice of cropping pattern and crop rotation.
- **Rahad 1:** The cultivable area is 117,600 ha (or 280,000 feddans). The typical farm of 15 feddans is divided into two equal courses of 7.5 feddans occupied by cotton (50%) and groundnuts or sorghum (50%).

- **New Halfa:** The cultivable area is 138,600 ha[9] (330,000 feddans). The typical farm size is 15 feddans. The crop rotation is Cotton – Wheat of Sorghum – Groundnut.

In the reality since the 1980's sorghum became the major crops in terms of areas in the three schemes and cotton has been trending downward. Table 6 gives, as an example, the actual cropping pattern in 2000/01 for the three main schemes. Sorghum is the main food crop in Sudan and is also a source of feed for livestock. However Agricultural Corporations require farmers to grow cotton because of its importance for the national economy and of course for the Agricultural Corporations themselves. The Agricultural Corporations provide considerable support to tenants for financing cotton inputs, not for the other crops. Since 2006, farmers in the Gezira irrigation schemes are free to choose their cropping pattern.

Table 6: Cropped areas for the various crops in the Gezira, Rahad I and New Halfa irrigation schemes in 2000 /01 growing season.

	Gezira		Rahad 1		New Halfa	
Crops	Ha x 1000	% total area	Ha x 1000	% total area	Ha x 1000	% total area
Cotton	84	21%	18	22%	18	30%
Sorghum	210	51%	42	51%	21	35%
Wheat	47	11%	0	0%	2	3%
Groundnut	68	17%	23	28%	19	32%
Total	**409**	**100%**	**83**	**100%**	**60**	**100%**

Figures compiled by the consultant

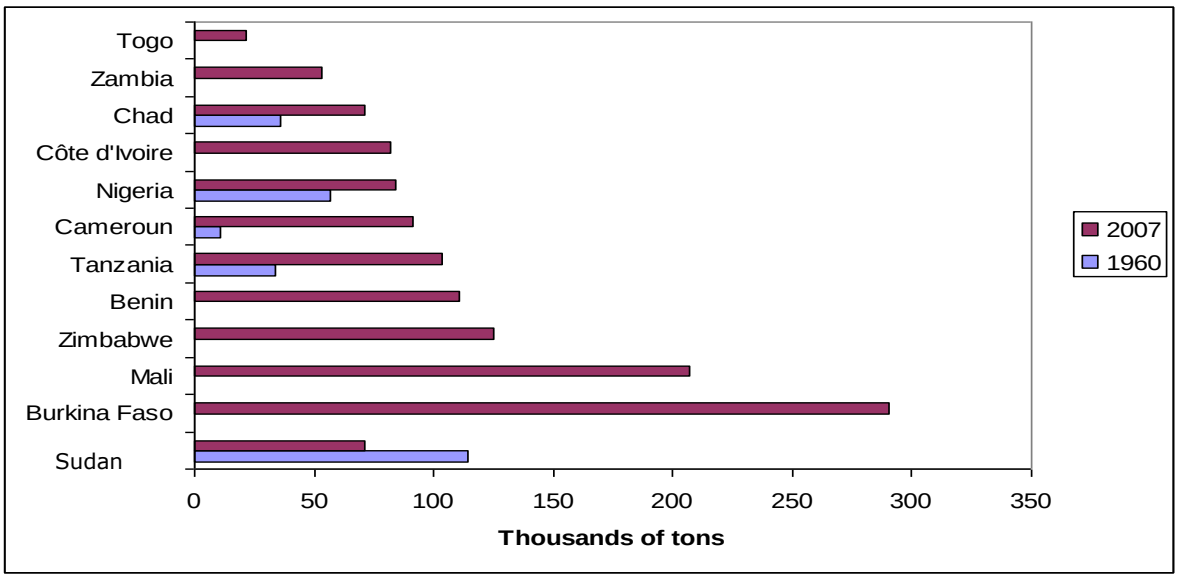
Based on the figures in table 6, cropping intensity was approx 50% in the Gezira and New Halfa scheme, 70% in Rahad I. These compare to theoretical cropping intensity of 100% in New Halfa and Rahad I; 80% in the Gezira according to prescribed cropping patterns.

It is worth pointing here that cotton production was multiplied by five in Sub Saharan Africa between 1960 and 2007 despite high subsidies in the USA, the first exporter in the world, and volatile world prices of cotton since the 1980's. In Sudan cotton production has significantly decreased over the same period (See figure 6).

Total production in Sub-Saharan Africa increased from 251,000 tons in 1960 to 1.3 million tons in 2007. In Sudan there is a decrease from 115 000 tons in 1960 to 72,000 tons in 2007. Centralized decision-making on cotton production management, such as use of herbicides and aerial spraying which affect tenants' costs substantially, inefficiencies in the institutional arrangements for processing, and marketing cotton and delays in payment to farmers are reasons often said for decrease of cotton area in Sudan.

[9] Area cultivated by tenants only, not including the sugar estate and other land use in the command area.

Figure 6: Cotton production in sub Saharan Africa in 1960 and 2007.



Source: United States Department of Agriculture (2007).

Yields

In spite of availability of technically proven and economically viable agricultural technology packages developed by the long established Gezira Research Station and Agricultural Research Corporation and extension services provided by the Agricultural Corporations, yields obtained by farmers are significantly less than achievable yields based research results. Table 7 makes a comparison between yields in Gezira Research Station and farmer's yields in the Gezira, Rahad I and New Halfa irrigation schemes.

Table 7: Comparison of research and farmers yields in Sudan irrigation schemes

Crops	**Farmers yields**	**Research yields**
Cotton extra long (Barakat): ton seed cotton / ha (Kantar seed cotton / feddan)	From 1.2 to 1.7 (From 3.5 to 5.0)	4.0 (12.0)
Cotton medium (Alcala) : ton seed cotton / ha (Kantar seed cotton /feddan)	From 1.7 to 2.0 (From 5.0 to 5.9)	6.1 (18)
Sorghum (hybrid): ton /ha	From 1.2 to 2.4	6.4
Wheat: ton /ha	From 1.4 to 2.0	4.8
Groundnut : ton /ha	From 2.5 to 3.0	4.8

Note on conversion: 1 kantar = 143 Kg; 1 feddan = 0.42 ha

The major reasons explaining the low yields in Sudan irrigation schemes is the lack of capacity of tenant farmers for financing the costs of hired labour and other inputs and sedimentation in irrigation infrastructures.

- *Lack of financing capacity of tenant farmers*: Tenant farmers rely on hired labour for their crops. Because of financing problems, farmers must economize on this cash expense. Hired labour used for supplementary land preparation, weeding and harvesting must be curtailed, which depresses yields even more. For cotton, farmers are supposed to receive cash advances from their Agricultural Corporation to cover the costs of hired labour. Agricultural Corporations also provide farmers with mechanized land preparation, seeds, fertilizers and pesticides. The costs associated with all these services are deducted from the tenant's individual account after the cotton is sold and the proceeds net of marketing costs and export tax are received from the Sudan Cotton Company. The current situation is that because of financing problems, the Agricultural Corporations can no longer finance inputs and labour cash advances in a sufficient or timely manner. Fertilizers procured by the Agricultural Corporations often arrive too late for planting, or in insufficient amounts; farmers have to finance an increasing part of the labour costs. The same service was offered for other crops but this has been discontinued and farmers have to deal with private inputs suppliers and money lenders. Farmers who are supplied fertilizers for cotton sometimes decide to use them for other crops or sell them to other farmers. There is no formal credit institution and this problem also affects rain-fed farmers nationally. Surprisingly in spite of relatively large tenancies, there was no accumulation of capital by farmers in Sudan public irrigation schemes. Even in the 80 years old Gezira scheme, tenants' individual accounts show large debt amounts; farmers' debts were cancelled twice in the past 25 years.

- *Sedimentation in irrigation infrastructures:* huge sedimentation problems in the Blue Nile schemes and New Halfa also affect yields. Origin of the problem is land erosion in Ethiopian highlands. Despite considerable efforts by the Ministry of Irrigation and Water Resources (in Khartoum the consultant was informed that some 70% of the total budget allocation for the water sector is used for de-silting hydraulic works), these do not keep pace with the rates at which silt is settling. For the Gezira scheme the Ministry of Water and Irrigation estimates the annual silt removal to be carried out at 16 million cubic metres. Consequences of the sedimentation problem are generally (1) decrease in conveyance capacity of canals, (2)"drowned" water control structures and (3) difficulties in supplying water to parts of the schemes (tail-end effect) and (4) reductions in cropped area. In short, sedimentation affects yields through decrease of reliability and equity of irrigation water supply.

- *Lack of water for winter crops*: From mid-October to mid-November, the most appropriate time to sow wheat or other winter crops, cotton should receive its most critical watering and groundnuts and sorghum are receiving their last irrigation before ripening. To ease the water constraint, the sowing of wheat is delayed, and this seriously lessens yield as water stored in dams (Roseires, Khashm El Girba) dwindles rapidly in winter.

2.3.6 Irrigation management and cost recovery

Irrigation management of Sudan public schemes has always been divided between the Ministry of Water and Irrigation and Agricultural Corporations managing the schemes. The Ministry of Water and Irrigation is responsible of dams management and Operation and Maintenance (O&M) of main (level 1) and major (level 2) canals. The Agricultural Corporations are responsible of O&M for the minor canals (level 3) and field canals (Abu Ishrin). In 1995, as part of the liberalization of the economy, the Government withdrew from financing the cost of irrigation services. Farmers were left to pay irrigation fees to the newly established Irrigation Water Corporation (IWC) a financially independent public institution, which used these fees directly to provide water supply services to the farmers.

Instead of the IWC setting up its own mechanism for collecting the fees directly from the farmers, it relied on the Agricultural Corporations managing the schemes to collect the fees from the farmers. The Agricultural Corporations collected water charges for cotton through the tenant individual account system. Water charges for other crops were collected directly from the tenants at harvest time. Irrespective of the fixed rates, the amount to be paid was based on the harvest rather than the cropped area and determined by the Agricultural Corporations Field Inspectors; no water charge was levied if crops failed.

As a consequence rates of water charges collection rates varied with agricultural production and did not exceed 60% and water charges did not cover maintenance costs let alone operation costs. Furthermore as the Agricultural Corporations were also facing considerable financial difficulties, part of the water fees collected did not reach the IWC and part of the collected fees paid to IWC was delayed for sometime as it was used for financing other urgent activities. The result of this was the inability of IWC to have the required budget to provide its services in a sustainable manner. This led to the accumulation of sediment in the irrigation canals, deterioration of the water regulation structures, machinery and pumps. By the year 2000 the IWC was bankrupt and was dissolved. At present, the MIWR is again responsible for the O&M of the irrigation canals up to the minor canals off-takes and the Agricultural Corporations for the lower levels of the irrigation systems. The Ministry of Finance and National Economy provides the MIWR with the annual budgets for operation and maintenance. Failure of this first tentative of recovering O&M cost from farmers led the government of Sudan to try other approaches first and solely in the Gezira irrigation scheme.

By 2001 in the Gezira Scheme, Minor Canal Committees had been formed along the minor irrigation canals and representatives of each of these committees constituted the Irrigation Committee at the major canal level. The Irrigation Committee with representatives of each of the minor canal committees took over the responsibility for O&M of the minor canals and below from the Sudan Gezira Board.

In 2005, a new law was passed for the Gezira scheme the main features are (1) establishment of legally recognized Water Users Associations (WUAs) at minor canal level in charge, (2) The Ministry should hand over O&M of minor canals and below to the WUAs after rehabilitation and supplies irrigation water at the head of minor canals under mutually agreed contract with the WUAs s and (3) Farmers are granted freedom in choosing their crops. There are now approx 1,700 WUAs in the Gezira irrigation scheme. It is too early for assessing the impacts of these reforms.

2.4 CHARACTERISTICS OF IRRIGATION DEVELOPMENT IN ETHIOPIA

2.4.1 Irrigated area and water use for irrigation

The total estimated area of irrigated agriculture in the country in 2005/2006 was about 340,000 ha, out of which 200,000 is traditional irrigation schemes built and managed by farming communities with minimum or no assistance from external bodies like the government or NGOs. Modern small scale irrigation covers 80,000 ha, size of the individual schemes is between 10s and 3,000 ha. However most of these schemes do not exceed 1,000 ha. Large public estates represent a total of 60,000 ha. Irrigation is still in its infant stage in Ethiopia where less than 10% of the irrigation potential of 3.7 million ha[10] has been developed. Table 8 gives a general picture of irrigation development in Ethiopia.

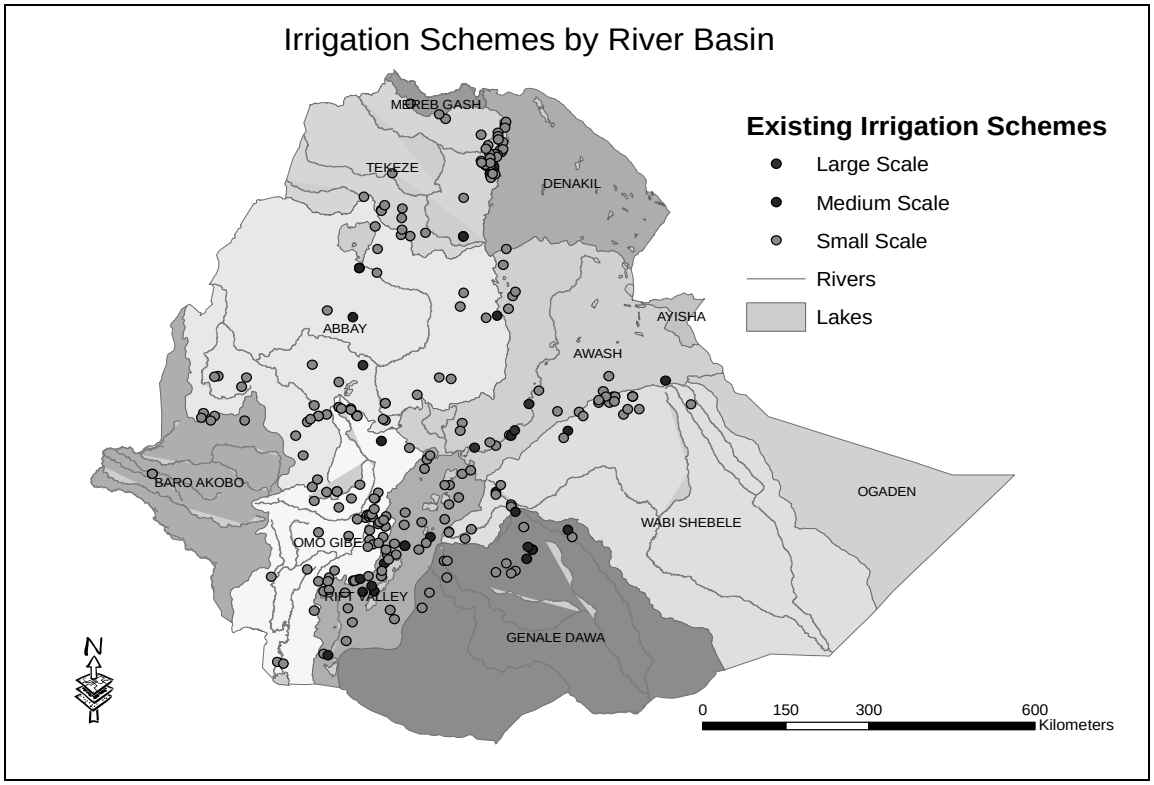
Table 8: Typology of irrigation in Ethiopia

Type of schemes	**Traditional irrigation**	**Modern Small scale irrigation**	**Large public estates**
Total area in country	200,000 ha	80,000 ha	60,000 ha
Percentage of total irrigated area	58 %	24%	18%
Total area in the Nile basin	60,000 ha	24,000 ha	8,500 ha (Finchaa sugar estate)
Size of individual scheme	10s of ha	10s of ha – 3,000 ha	More than 3,000 ha
Construction by	Communities	Government or NGO	Government*
Management by	Communities	Irrigation cooperation	Public enterprise

* First large estates were actually built by private foreign companies in the 1950's.

[10] Source MoWR, 2002; World Bank, 2006.

Figure 7: Spatial distribution of irrigation schemes in Ethiopia.



Source: IWMI (2007)

In terms of spatial distribution, The Awash basin and the Rift valley have the bulk of the share of irrigated agriculture. Figure 7 shows the location of irrigation schemes for which geo-references are available. It gives an idea of the spatial distribution of irrigated areas in the country. Information on water use for irrigation in Ethiopia is not available.

2.4.2 Irrigation and drainage technology

Ethiopian irrigation schemes are gravity fed and involve either river diversions or dams. Water is distributed in earthen canals. Most of the schemes are poorly equipped with water control and measurement structures. Manually operated gates are used for water partition. Most traditional irrigation schemes have to be re-built each year after the rains and flood that destroy intakes and canal networks. Field irrigation methods are unlevelled basins or short furrows in small scale irrigation scheme. Large estates use long furrows or basin irrigation; some of them are equipped with sprinkler irrigation (i.e. Finchaa Sugar Estate).

Generally, no drainage system is built on small scale irrigation schemes that have to rely on natural drainage. In large public estates faulty drainage system and over-irrigation have led to salinity and abandon of thousands of hectares. Considerable efforts are being made to remediate this problem.

2.4.3 Land tenure

In Ethiopia the land is owned by the government. Farmers have landholding (or usufruct) rights with no limit of time. Landholding can be individual for arable land or communal for pastoral land. Any person residing in a rural area and wanting to undertake agricultural activities is entitled to be provided with a landholding by the local administration. The minimum size of landholding per person is determined by the fertility of land and fixed by the local administration.

The Regional governments can also provide private investors with larger landholdings; this happens only in the lowlands where population density is low. Officially, landholding rights can be transmitted by donation or inheritance. Some international donors advocate for private land ownership that would increase agricultural productivity. On the other hand the current legislation avoids speculation on land and exclusion of the poorest farmers.

Generally, land to be cultivated by modern irrigation is redistributed. In modern small scale irrigation, landholding size per beneficiary is generally about 0.25 ha. In Koga, the first large irrigation scheme that is under construction, landholding per beneficiary was fixed to 1.5 ha. The land holders who lost their landholdings because of construction of dams and irrigation infrastructures are provided with irrigable land compensation and/or are paid reparation.

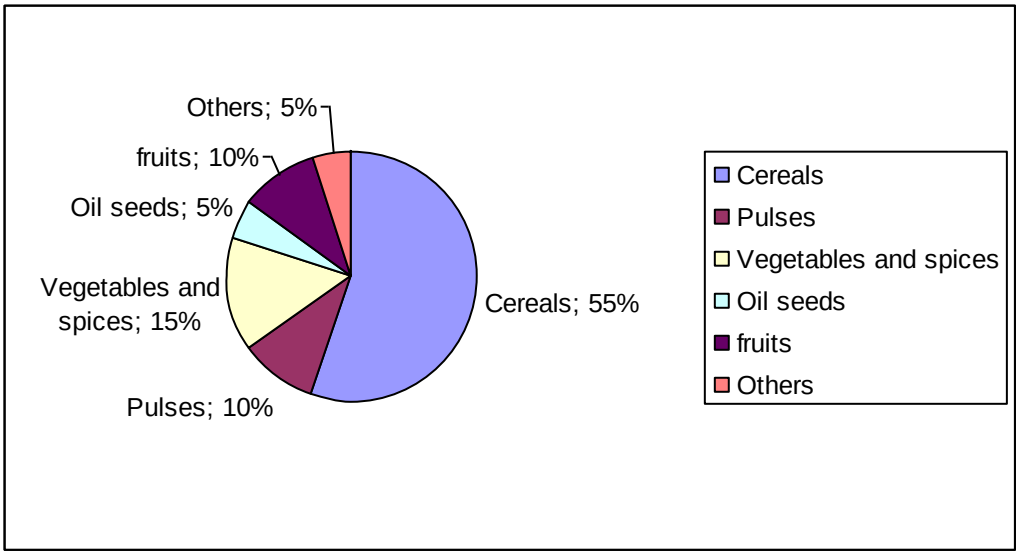
2.4.4 Agricultural production

Cropping pattern

Major crops on large public estates are sugar cane, cotton and to a lesser extent fruits and vegetables. Traditional and modern small scale irrigation schemes grow cereals as main crops. During the rainy season most of the schemes grow cereals (teff, maize and barley), pulses and oil seeds with supplementary irrigation. In the dry season, farmers cultivate cereals and a range of vegetables and spices. Perennial crops such as sugar cane, bananas or quat are also grown; they are sometimes intercropped with annual crops. Figure 8 show the typical cropping pattern in small scale irrigation schemes.

The typical cropping pattern of small scale irrigation and rain-fed agriculture are quite similar, dominant crop are food crops (cereals, pulses). Small scale irrigation does not replace rain-fed agriculture but complement it. However many small scale irrigation schemes do not fit in this general picture and are highly specialized as a result of market opportunities. For instance most of the schemes in the Rift Valley grow only vegetables for the markets of Addis Ababa and Djibouti. Other schemes in the region of Harar in Eastern Ethiopia are specialized in quat production.

Figure 8: Typical cropping pattern in small scale irrigation schemes in Ethiopia.



Source: IWMI 2007

Yields

Yields obtained by farmers in small scale irrigation schemes are low, for instance less than 2 tons/ha for maize versus a reasonable benchmark of 6 tons/ha. Yields vary considerably between irrigation schemes and between farmers within one irrigation scheme. Main factors affecting yields are:

- Quasi-absence of extension service for providing support for managing small scale irrigation systems;
- Poor maintenance and degradation of irrigation canals
- Difficulty in sourcing inputs: high cost of inputs, quasi-absence of credit, lack or shortage of inputs in due time for planting;
- High maintenance labour requirement and difficulty in water distribution due to sedimentation in canals and, for traditional schemes, to repair locally made scheme intakes.
- Low selling prices of products at peak supply period;
- Poor market access due to distance and poor road status.

Irrigation management and cost recovery

Traditional irrigation schemes are managed by community-based committees often led by elected leaders, "The Water Fathers"; traditional committees are in charge of operation and maintenance activities and conflict resolution. Modern irrigation schemes are managed by irrigation cooperatives, which are meant to combine O&M and marketing activities.

There is also a growing consensus among irrigation stakeholders in Ethiopia on the fact that mixing up O&M and marketing activities in one organization (an irrigation cooperative) increases the difficulty of irrigation management and creates confusion amongst irrigating farmers. It is more and more widely agreed that organizations such as Water Users Associations (WUAs) are the most appropriate institutions to deal with the "forced cooperation" that O&M implies, and cooperatives should remain voluntary-based farmers' organizations. Ethiopia Irrigation Policy wants "to promote the establishment of appropriate institutions and develop human capacity in irrigation engineering and management"; however there is currently no legal status for Water Users Associations in Ethiopia.

Government support to modern small scale irrigation is provided through three Institutions of the Regional States:

- The Regional Bureaus of Water Resources (BoWR) are in charge of the design, supervision of construction by Regional Water Work Enterprises or private contractors, and major maintenance opposed to minor maintenance (canal cleaning) done by farmers. Due to financial constraints, major maintenance activities are not fully responding to the actual needs and infrastructures of modern irrigation schemes are often degraded.
- The Regional Bureaus of Agriculture and Rural Development (BoARD) provides irrigating farmers agricultural extension service. However extension activities are oriented toward the largely dominant rain-fed agriculture and no special consideration is given to irrigated agriculture.
- The Regional Cooperative Promotion Agencies (CPA) is responsible of establishing and empowering of the irrigation cooperatives.

Generally, there is little coordination and no common strategy for irrigation development and management. In Amhara Region, senior officers of the three institutions recognize that this institutional set up is not operational and have started consulting each other for exploring solutions to remedy the problem.

Cost recovery

In traditional irrigation schemes, cost recovery rate is 100%: farmers maintain and operate the schemes without external assistance. In modern small scale irrigation schemes farmers participate in labour solely to minor and major maintenance.

In general no irrigation fee in cash is levied. As a result, all maintenance work involving cash costs even limited to the purchase of a few bags of cement and the service of a local mason is considered as major maintenance by farmers.

2.5 CONTRIBUTION OF IRRIGATION TO THE NATIONAL ECONOMY AND POVERTY REDUCTION

2.5.1 Egypt

In Egypt, all agricultural production including livestock comes from irrigated agriculture. Egypt Gross Domestic Product was 82,400 million USD in 2006. Irrigated agriculture contributes to 16% of GDP and employs 30% of the total economically active population. Irrigated agriculture is characterized by small farms, O & M at no charge for farmers, high inputs / high outputs technology and high labour intensity. Gross margins per ha are in the range of 1,000 USD / ha for cotton and cereals (see table 9) and are probably much higher for horticultural crops.

Table 9: Yields, products, and margins of cotton and cereals in Egypt

Crops	Average yields (ton/ha)	Farm gate price (USD/ton)	Product (USD/ha)	Production cost (USD/ha)	Margin (USD/ha)
Cotton	2.6	489	1,271	160	1,111
Wheat	6.4	185	1,184	133	1,051
Rice	9.4	130	1,222	137	1,085
Maize	8.4	130	1,092	115	977

Source: National agricultural statistics

Average yields clearly show the benefits of the Green Revolution. However gains of productivity have eventually allowed maintaining the large farming population (average farm size of 1.5 feddan) just above poverty line. Liberalization of the land market is likely to lead to some degree of land concentration and exclusion of the poorest farmers who will have to find off farm job opportunities either in rural areas or Cairo. Beside desert land reclamation, the aim of land use planning in Egypt is to change cropping pattern in such a way that crops are cultivated on relatively large areas to allow mechanization practices and rationalizing pest control; this supposes the establishment of farmers' organizations.

2.5.2 Sudan

The GDP of the Sudan was US$17.8 billion in 2006. The agricultural sector is the most dominant in the country's economy, even though its share has declined recently because of increased exploitation and export of oil. The sector contributes over 39 % to the GDP and employs 57 % of the total economically active population. It contributes about 90 % of the Sudan's non-oil export earnings.

Irrigated agriculture covers 10% of the total cultivated land but it contributes to about 50% of crop production in volume. Irrigated agriculture has become more and more important over the past few decades as a result of drought and rainfall variability and uncertainty. It remains a central option to boost the economy and alleviate poverty in rural areas.

Rain fed agriculture covers approx 15 million ha. The cultivated area and yields vary considerably from year to year depending on rainfall. The traditional rain fed farming covers approx 10 millions ha. It is characterized by small farm size, labour-intensive cultivation techniques employing hand tools, low input level and poor yields. Mechanized rain-fed agriculture covers 5 million ha and comprises about 10,000 large farmers with farm sizes of 400-850 ha and a few large companies with holdings of more than 10,000 ha.

Based on data about production costs and farm gate prices given by the Gezira Board socio-economic unit, gross margin per ha in the Gezira irrigation scheme varies between 160 and 300 USD /ha according to yields obtained by farmers and actual cropping pattern. Details are given in table 10. This is equivalent to between 1,330 and 2,850 USD for a tenancy of 20 feddans (8.3 ha). For an average tenant family of five persons, annual income is between 0.73 and 1.56 US dollar per person and per day; insufficient for capital accumulation. This does not include income from off farm activities and livestock, which are known to account for more than 50% of tenants' incomes.

Table 10: Estimation of gross margin in the Gezira irrigation scheme

Crops	Alcala cotton		Wheat		Sorghum		Groundnut	
Yield: ton/ha	1.7	1.2	2.0	1.4	2.4	1.2	3.0	2.5
Farm gate price USD/ton	541	541	190	190	110	110	137	137
Production costs USD/ha	285	285	167	167	78	78	91	91
Gross Margin : USD/ha	635	364	213	99	186	54	319	250
% cropped area	21%	21%	11%	11%	51%	51%	17%	17%

Main factors affecting irrigation productivity in Sudan are:

- *Sedimentation in dams and canals*: the origin of sedimentation in Sudan water infrastructures is erosion in the Blue Nile catchment in Ethiopia. Initially the total storage capacity of the Roseires dam was 3 BCM and live storage 2.4 BCM. At present the total capacity of the dam is about 2.2 BCM, meaning part of the live storage is now silted up. Decrease in the water regulation capacity has led to increasing use of water in late July, early August when the sediments concentrations are at the highest and serious constraints on cropping pattern and crop rotation in the Blue Nile schemes. Heightening of the Roseires dam will alleviate the problem for sometimes. The long term solution is trapping sediments though dam construction and watershed management in Ethiopia. The Khashm El Girba dam on the Atbara River supplying water to the New Halfa scheme is also largely silted up.

- *Outdated tenancy system*: The tenancy system was designed in the 1920's for the Gezira irrigation scheme and has served as a model for the other large public schemes. It has become increasingly unsatisfactory as a result of social and economic changes. The tenancy size is too small to allow mechanized agriculture and too large for efficient application of labour intensive technology. Tenant farmers rely on hired labour or engage in share cropping practices; the consequence being low yields and low productivity. Furthermore the current tenancy system does not allow the formal sale of tenancies eliminating the option for existing tenants to retire from irrigated farming and for new entrants to invest.

- *Difficulties in financing irrigated agriculture*: because of financing problems, the Agricultural Corporations can no longer finance inputs and labour cash advances in a sufficient or timely manner. Farmers have to finance an increasing part of the inputs and labour costs but there is no formal credit institution. Main causes of financing problems of Agricultural Corporations are steady decrease in cotton area and low recovery rate of the O&M fee. Centralized decision-making on cotton production management, such as use of herbicides and aerial spraying which affect tenants' costs substantially and inefficiencies in the institutional arrangements for marketing cotton and payment to farmers are the reasons often said for reduction of cotton area. Low recovery rate of the O&M fee is linked to unsatisfactory water distribution due to the sedimentation problem and past failed attempts to establish an efficient O&M cost recovery system.

- *Lack of water in the cold season*: Water stored in dams rapidly dwindles in the cold season; this affects the yields of wheat and the other winter crops.
- *Poor drainage condition combined with excessive water application.*

2.5.3 Ethiopia

Ethiopia GDP was 11.5 billion USD in the fiscal year 2005/06. Agriculture contributes for 44% of the GDP and employs about 80% of the economically active population.

Irrigation is still in its infant stage in Ethiopia. It covers approx 340,000 hectares compared to the 12 millions hectares under rain fed agriculture. Although the large public estates provide the bulk of sugar and cotton production, contribution of irrigated agriculture to the national economy is insignificant. For the Ethiopian government, irrigation is a key to improving the Ethiopian economy and alleviates poverty. Accordingly the PASDEP[11] 2005 – 2010 plans the development of 487,000 ha under irrigation and 59,000 ha under other forms of agricultural water management such as water harvesting.

A study by IWMI in 2007 shows that gross margins in small scale irrigation schemes vary between 350 and 500 USD per hectare which is three times more than average margins in rain fed agriculture (120 -160 USD per hectare). Despite the constraints limiting irrigation productivity, small scale irrigation is a significant contribution to poverty reduction of the (few) beneficiaries.

[11] Plan for Accelerated Sustainable Development and Eradication of Poverty; Ministry of Finance and Economic development.

3. Part II: Transboundary analysis

3.1 INTRODUCTION

All Eastern Nile countries have ambitious irrigation expansion projects. Water resource availability for doing so is obviously a major challenge. Egypt wants to develop 1,117,200 Ha of new land under irrigation by reclaiming desert land in Upper Egypt and in the Nile Delta. For the Egyptian government, expansion of irrigation is a necessity for responding to needs of the country growing population. In Sudan, irrigated agriculture has become more and more important over the past few decades as a result of drought and rainfall variability and uncertainty. It remains a central option to boost the economy and alleviate poverty in rural areas. Ethiopia wants to develop the potential of its huge water resource for poverty alleviation and food security purposes; its Plan for Accelerated Sustainable Development and Eradication of Poverty (PASDEP) for the period 2005 – 2010, indicates a target of 487,000 hectares of new irrigation development.

The transboundary analysis first presents the irrigation expansion projects of the three Eastern Nile countries. For doing this, we have adopted a territorial approach based on the following principles:

- Delimiting relatively homogeneous areas called "Irrigation Development zone" within the Eastern Nile basin regarding irrigation development, agro-ecology and their socio-economic characteristics;
- Adopting a "without border" approach to delimit irrigation development areas unless administrative boundaries correspond to homogeneous irrigation development areas.
- Respecting Integrated Water Resources Management (IWRM) principles by taking into account sub-basins and large reservoirs for delimiting the irrigation development areas.

In the second part the challenges and opportunities related to irrigation development are analyzed according to the essential elements for successful irrigation development and management:

- Hydrology: Availability and reliability of water supply in time and space; quality of the water resource.
- Policies governing and assigning priorities to irrigation investments; and ensuring long term productivity of developed irrigation.
- Institutions: Definition of their roles and responsibilities for the provision of a specific service to irrigated agriculture. Institutions refer here to public services, farmers- controlled organizations and private sector entities.
- Technology: Irrigation technology to deliver water to irrigated farms in a steady, predictable and reliable manner; agricultural technology to ensure high productivity.

3.2 IRRIGATION EXPANSION PROJECTS

The total area of the planned irrigation expansion projects in the Eastern Nile basin amounts to 3.2 million hectares. The total irrigation water requirement of these projects is 42.3 BCM (table 11). Irrigation water requirements are higher than water actually consumed through evapotranspiration. Typically water consumed in irrigation is 40% to 60% of irrigation water requirements. Assuming (very optimistically) that excess diverted water for irrigation would return to the river system, implementing all the planned projects would increase water consumption by approx 20 BCM.

Table 11: Areas and water requirements of irrigation expansion projects in the Eastern Nile

Country	Sub-basin (Irrigation Development Zone)	Net area (Ha)	Gross annual water requirements (MCM)
*Ethiopia	Abay (IDZ 1,2 & 3)	711,000	6,006
	Tekeze (IDZ 4)	302,000	4,551
	Baro- Akobo	483,000	6,520
Sub-total Ethiopia		***1,496,000***	***17,077***
Egypt	Upper Egypt (IDZ 6)	658,560	13,120
	Delta (IDZ 7)	458,640	6,953
Sub-total Egypt		***1,117,200***	***20,073***
Sudan	Blue Nile (IDZ 3)	1,061,500	10,084
	Atbara (IDZ 4)	99,000	1,881
Sub-total Sudan		***1,160,500***	***11,965***
Grand total		**3,773,700**	**49,115**

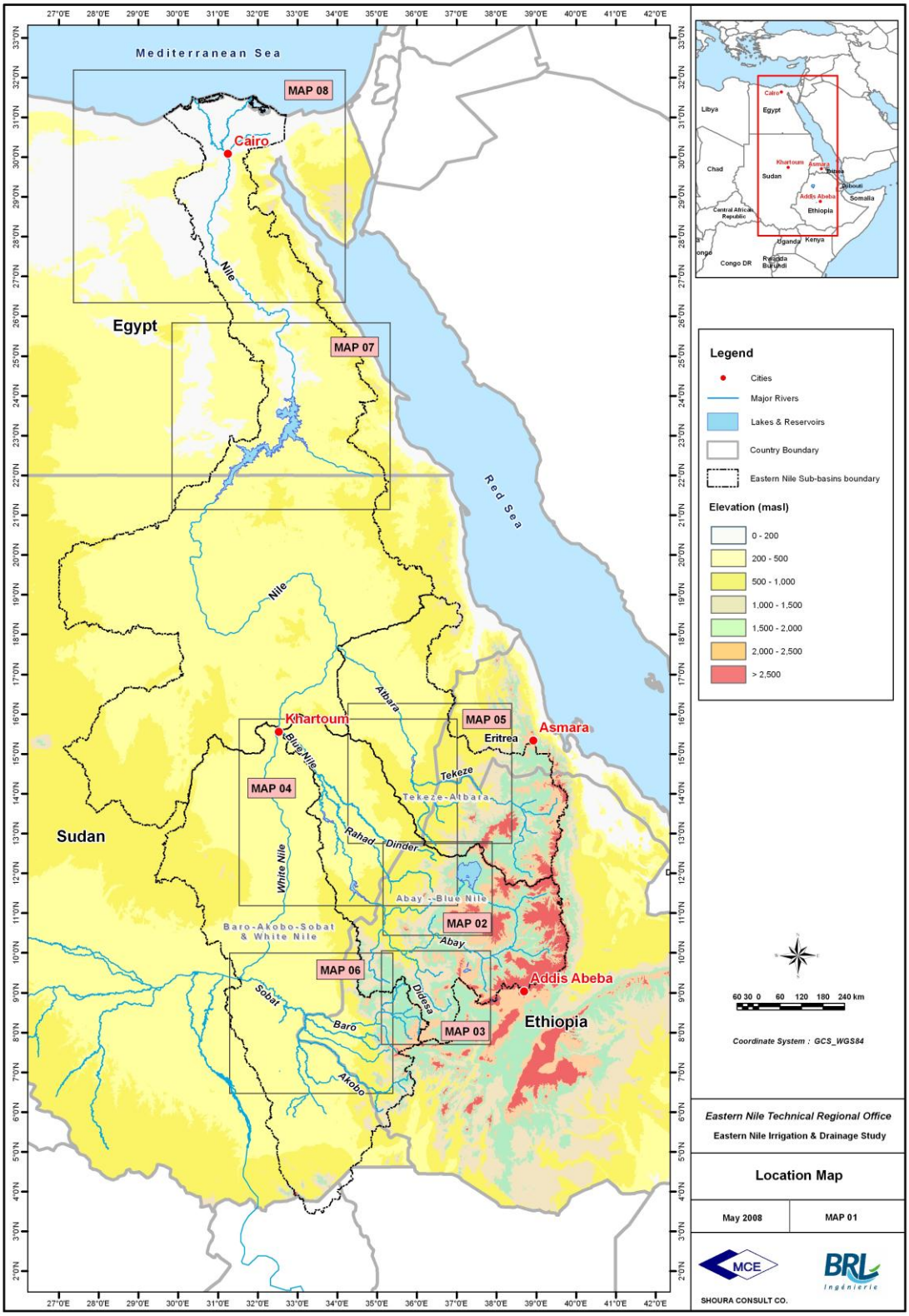
*Areas of irrigation projects in Ethiopia do not include land suitable for pressurized irrigation

Table 11 presents irrigation projects that are identified in the countries master plan which were elaborated in a unilaterally manner, in other words, without considering impact of irrigation development in upstream or downstream countries. The figures were approved by the country national coordinator. The consultant does not presume of the technical and financial feasibility of these projects nor of the intention of each country to claim additional water to achieve all of them. For instance Egypt plans to implement irrigation development by improving overall water use efficiency, increasing water supply at Aswan through upstream water conservancy projects and by reducing the Nile flow to the Mediterranean Sea. Furthermore, water requirements are based on assumptions regarding irrigation efficiency and cropping patterns and thus should be considered as indicative.

The following is a presentation of the irrigation expansion projects in each of the delimited Irrigation Development zone of the Eastern Nile basin. For projects indicated in the Terms of Reference of the engineering component of this study, the diagnosis report of the engineering component gives a much more detailed description of the proposed irrigation projects. To have a better understanding of the opportunities and challenges of irrigation development at the basin level, we have added the irrigation projects in Egypt and projects in Sudan which are not listed in the ToR, these projects are not further described under the engineering component of the present study.

Map 1 shows the irrigation development zones (IDZ) in the Eastern Nile basin.

Map 1: Irrigation development zones in the Eastern Nile basin *(print pdf map on A4 paper)*



3.2.1 IDZ 1: Lake Tana and Beles sub-basins in Ethiopia.

The Lake Tana Basin and the Upper part of the Beles basin are located in the Amhara regional state, the lower part of the Beles basin is in the Benishangul-Gumuz Region. The Lake Tana basin is characterized by high population density, subsistence farming with an average land holding of less than one hectare. The Beles sub basin, on the other hand, is sparsely populated most of the land is covered by forest. The limited population lives by livestock breeding: sheep and goats, hunting and shifting cultivation.

The Tana sub-basin, given its significant water resources (Lake Tana with a dynamic water storage of 9-12 BCM), its rich cultural and natural assets, relatively developed urban centres (Bahir Dar, Gondar) with good roads and air connectivity, and dense settlements has a potential for growth in multiple sectors with strong multiplier effects, namely, agro-industry and export, but also tourism, fisheries and energy (potential: 700 MW) and therefore can serve as a stimulus to national economic growth. The first large scale irrigation scheme with smallholder farmers in Ethiopia (Koga, 6,000 hectares) is located in this zone and is currently under construction. Lake Tana and Beles basins are not connected but a tunnel is under construction to transfer water from Lake Tana into the upper Beles for hydropower and irrigation development purposes. The Beles basin is a potential area for large scale commercial farming. At present there is no road linking Lake Tana area and Beles sub-basin.

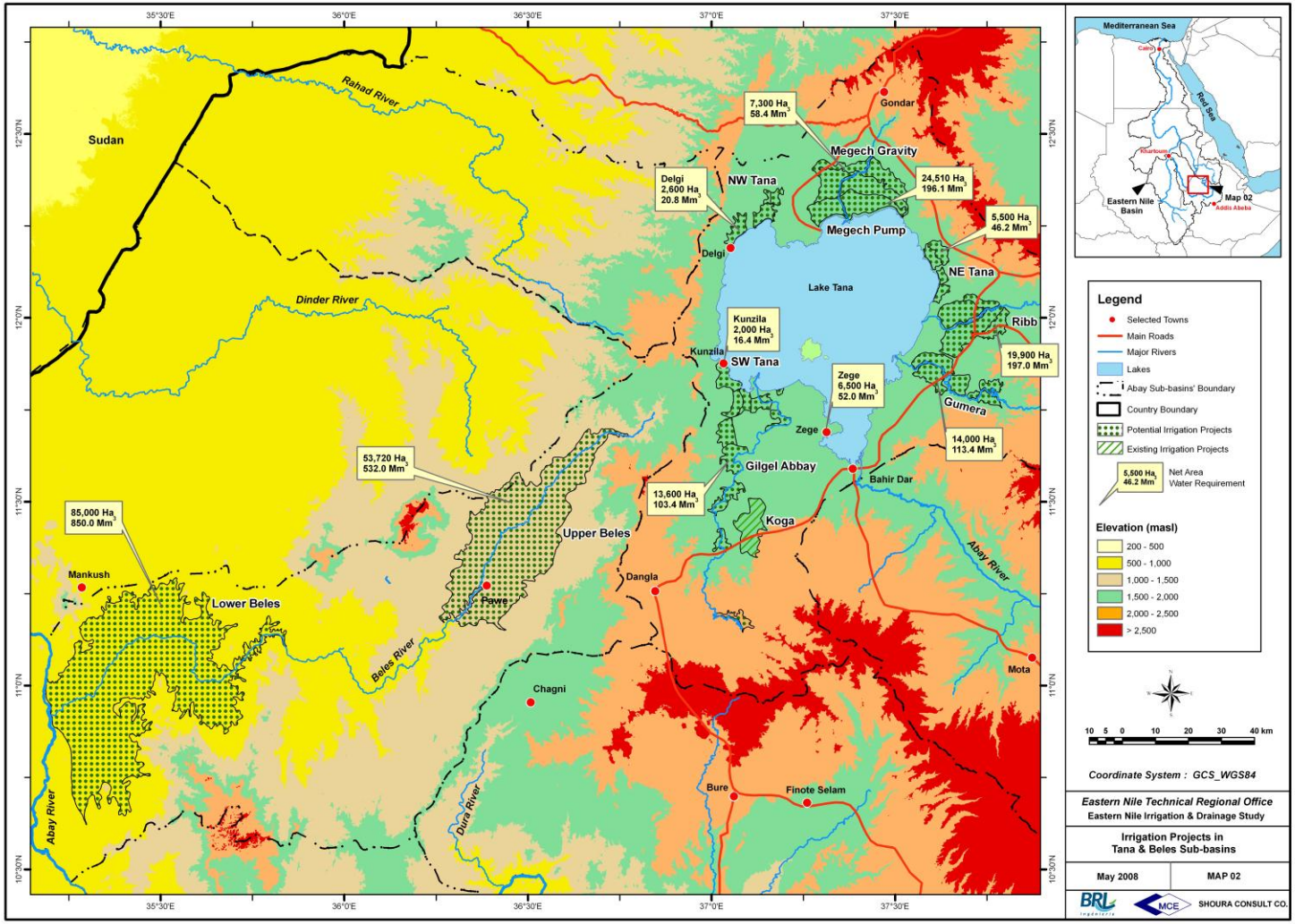
Based on the opportunities described above, the **Tana Beles Integrated Water Development Programme** (TBIWRDP) will aim at creating the enabling environment for improved development and management of land and water resources of the Tana and Beles sub-basins to contribute to accelerated growth and sustainable socio-economic development. A series of thematic studies are ongoing in preparation of the programme. The proposed irrigation projects are "Lake Tana shores projects" involving either dam on tributaries of Lake Tana or direct pumping from the Lake. Upper and lower Beles irrigation projects involve river diversions and are dependant of the completion of the Tana – Beles tunnel. Main characteristics of these projects are given in table 12. See map 02 for the location of project.

Table 12: Projects, area and water requirement in Tana & Beles sub-basins

Name of projects	Net Area (Ha)	Unit water requirement (m^3 /ha/year)	Annual water requirement (MCM)	Status
Megech gravity	7,300	8,000	58.4	Committed
Megech pump	24,510	8,000	196.1	Committed
Ribb	19,900	9,000	179.1	Committed
Gumara	13,980	8,100	113.2	Committed
Gilgel Abbay	12,850	7,600	97.7	
North East Tana	5,750	8,400	48.3	
North West Tana	6,720	8,000	53.8	
South West Tana	5,130	8,200	42.1	
Tis Abay*	11,300	8,300	93.8	
Zege	6,500	8,000	52.0	
Upper Beles	53,700	9,900	531.6	Committed
Lower Beles	85,000	10,000	850.0	
TOTAL	**252,640**		**2,316.0**	

Source: Abbay Master plan / Phase 2 / Volume V: Irrigation (figures for areas were rounded to the nearest hundred of hectare). * Not shown on map 02.

Map 2: IDZ1: Lake Tana and Beles sub-basins *(print pdf map on A4 paper)*



3.2.2 IDZ 2: Anger, Didessa and Finchaa sub-basins in Ethiopia

This zone has significant land and water resources, the Didessa River alone accounts for 20 % of the Nile flow at the Ethiopia-Sudan border. However irrigation development is dam dependant because of the high seasonality of the rivers flow. Good agricultural land is available in plenty and is sparsely cultivated at present.

This zone is sparsely populated; population density does not exceed 30 persons/km2 and is generally much less. A Resettlement Program from densely populated Hararghe and Arsi zones of Eastern Oromya region started in 2004 and is continuing. The Resettlement Programme is accompanied by the provision of basic social services such as health, drinking water and the tsetse fly control programme based in Bedele.

The zone is a potential for large scale commercial irrigated farming. Under-developed local markets do not offer any opportunity for marketing surplus of smallholder production; so far the Resettlement Program has been a transfer of subsistence farming. Furthermore, mechanisation obviously overcomes the problem of animal traction in areas of endemic tsetse infection.

Development of large commercial farming has the potential for synergy with the resettlement program through job creation and contract farming with out-growers. Such an integrated development program would be dependant of government services provision such as education, health and improved road access.

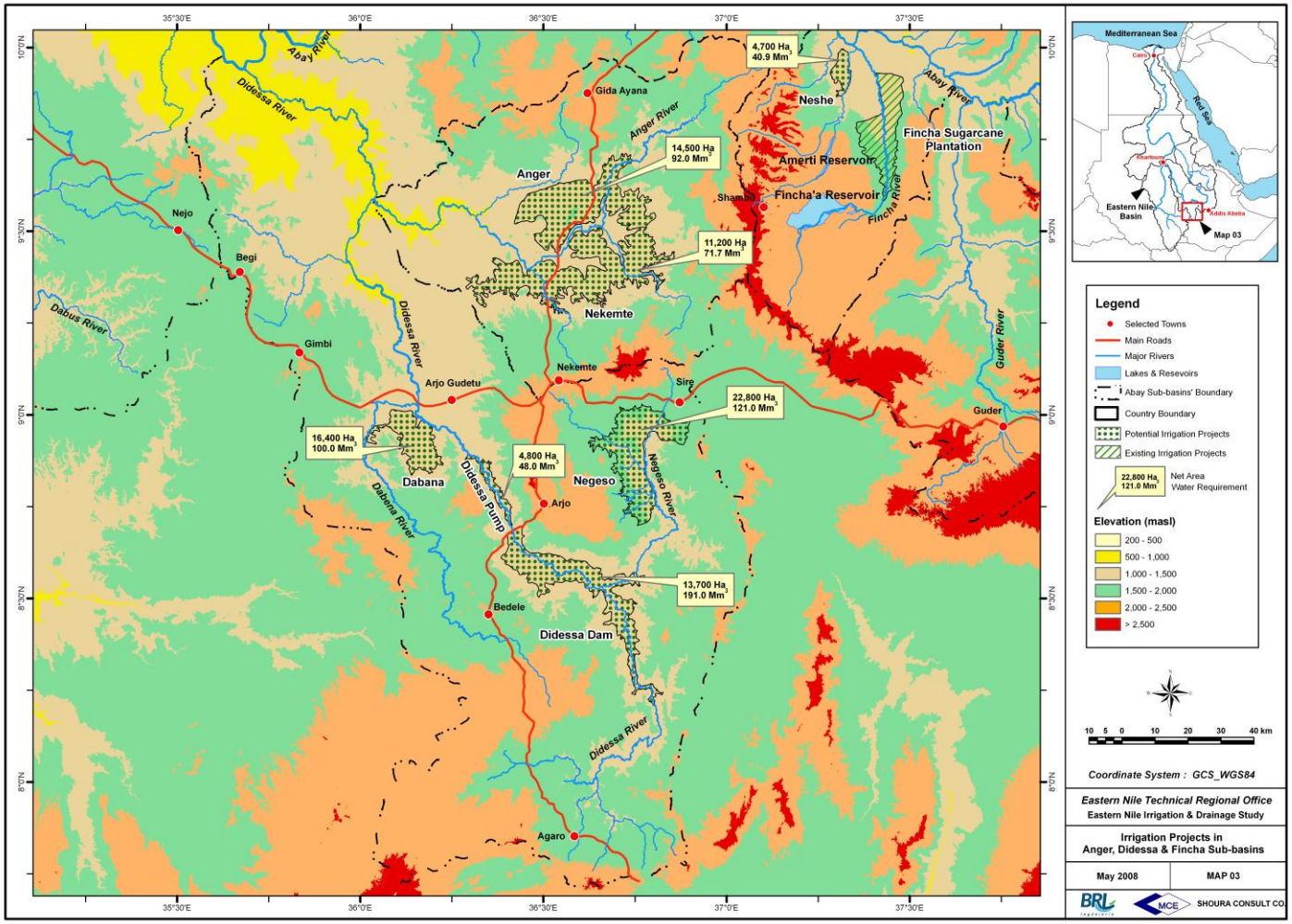
All the proposed irrigation projects except one are dependent on dam construction on tributaries of the Nile. Main characteristics are given in table 13. Locations of projects are shown on map 03.

Table 13: Projects, area and water requirement in Anger, Didessa and Finchaa sub-basins

Name of projects	**Net Area (Ha)**	**Unit water requirement (m^3 /ha/year)**	**Annual water requirement (MCM)**
Arjo Didessa dam	13 700	14 000	191,8
Didessa pumping	4 800	10 000	48,0
Negeso River	23 000	5 300	121,9
Angar	14 450	6 400	92,5
Nekemte	11 220	6 400	71,8
* Didiga	4 600	6 100	28,1
* Warm/Urg	3 260	6 300	20,5
Dabana river	16 390	6 100	100,0
* Dimtu/Hida/Lugo	2 000	6 100	12,2
Nesh	4 700	8 700	40,9
* Dabus pumping	5 100	7 200	36,7
* Dabus gravity	4 560	7 200	32,8
*Small Irrigation projects	236 000	7 000	1 652,0
TOTAL	**343 780**		**2 449,2**

Source: Abbay Master plan / Phase 2 / Volume V: Irrigation and comments from the MOWR of Ethiopia.
*Projects not listed in the TOR of the engineering component are not shown on map 03.

Map 3: IDZ 2: Anger-Didessa-Finchaa sub basins *(print pdf map on A4 paper)*



3.2.3 IDZ 3: Blue Nile and Dinder and Rahad tributaries in Ethiopia and Sudan

The Blue Nile region comprises the Gezira State and part of the Gedaref state. It is the most developed region in Sudan in terms of socio- economic infrastructure, i.e. roads, railways, agro-processing plants, telephone lines, agricultural research centres, health and education services. The Region is well connected to Khartoum and Port Sudan. In this zone, existing irrigation schemes cover a total area of about 1.3 million hectares or 70% of irrigated area of the country. The irrigated areas have attracted migrant workers and have a high density of population. The flat clay plain of the Blue Nile region has a potential of 3.3 million ha (source Nile Water Study, 1978). Both the socio-economic and physical characteristics of this zone make it the most obvious region for irrigation development not only in Sudan but also in the entire Eastern Nile basin. In the 1960's and 70's, Sudan was considered as the future "bread basket" of the Arab world. The limiting factors of future irrigation development are sedimentation in dams and irrigation canals, and water availability. The latest constraint will soon be partially alleviated with the heightening of the Roseires dam by ten metres.

The lower part of the basin of the Dinder and Rahad basins in Ethiopia can be attached to the Blue Nile region in Sudan. Proposed irrigation projects are located at the border with Sudan. The zone is sparsely populated and isolated and its potential market outlets are in Sudan, not Ethiopia. Main characteristics of proposed irrigation projects are given in table 14.

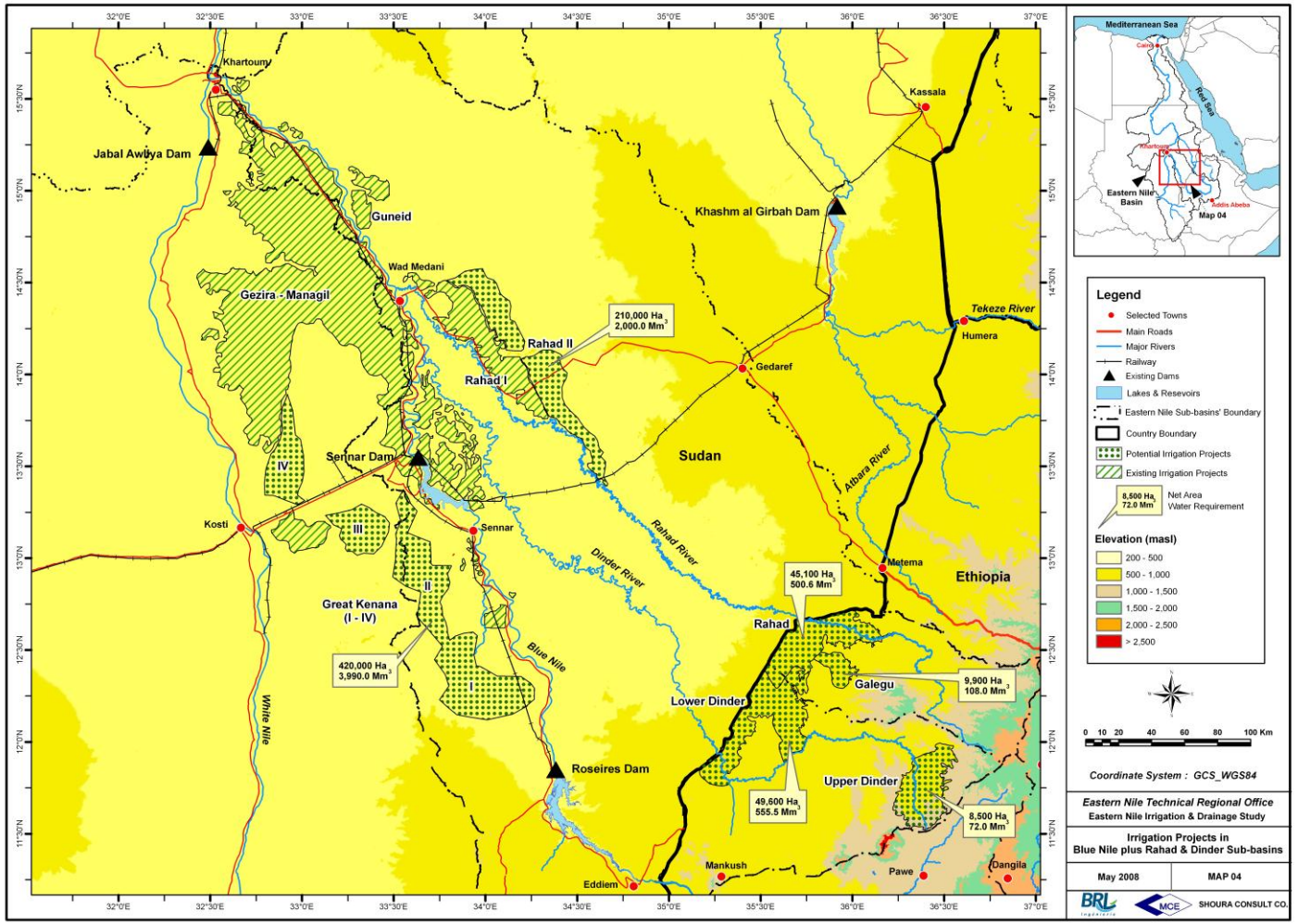
Table 14: Irrigation projects in the Blue Nile and Dinder Rahad tributaries

Name of projects	Net Area (Ha)	Unit water requirement (m^3 /ha/year)	Annual water requirement (MCM)	Status
Ethiopia				
Upper Dinder	10,000	9,000	90.0	
Lower Dinder	49,550	11,000	545.1	
Rahad	45,130	11,000	496.4	
Galegu	9,900	11,000	108.9	
Subtotal Ethiopia	**114,580**		**1,240.4**	
Sudan				
Rahad 2	210,000	9,500	1,995.0	Committed
Great Kenana	420,000	9,500	3,990.0	Committed
* Roseires	195,600	9,500	1,858.2	
Dinder South	67,000	9,500	636.5	
Dinder North	168,900	9,500	1,604.6	
Sub-Total Sudan	**1,061,500**		**10,084.3**	
Grand Total	**1,176,080**		**11,324.6**	

Source: Abbay Master plan / Phase 2 / Volume V: Irrigation and Nile Water Study / Irrigation report.
*Projects not listed in the TOR of the engineering component are not shown on map 04.

Map 04 shows the location of the proposed projects in this development zone. Roseires, Dinder South and Dinder North projects were added to comply with the comments made during the stakeholders workshop in Khartoum in August 2008. These three projects are not shown on the map.

Map 04: IDZ 3: Blue Nile plus Rahad, Dinder sub-basins *(print pdf map on A4 paper)*



3.2.4 IDZ 4: Tekeze – Atbara sub basins in Ethiopia and Sudan.

Total water resource of the sub-basin is estimated at 8 BCM. However irrigation projects are dam dependant; in the dry season Tekeze river flow is only about 5 m^3/second and dry season flows of Angereb, Goang and Gendua Rivers are almost zero. Vertisols are the dominant soil type in the project sites.

Project sites are served by The Gondar- Metema- Gedaref road, The Khartoum - Gedaref – Kassala-Port Sudan road and railway and the Humera - Andaselassie road. The zone is sparsely populated by subsistence farmers and pastoralists. Obvious potential markets for agricultural surplus are in Sudan, local markets in Ethiopia are almost inexistent.

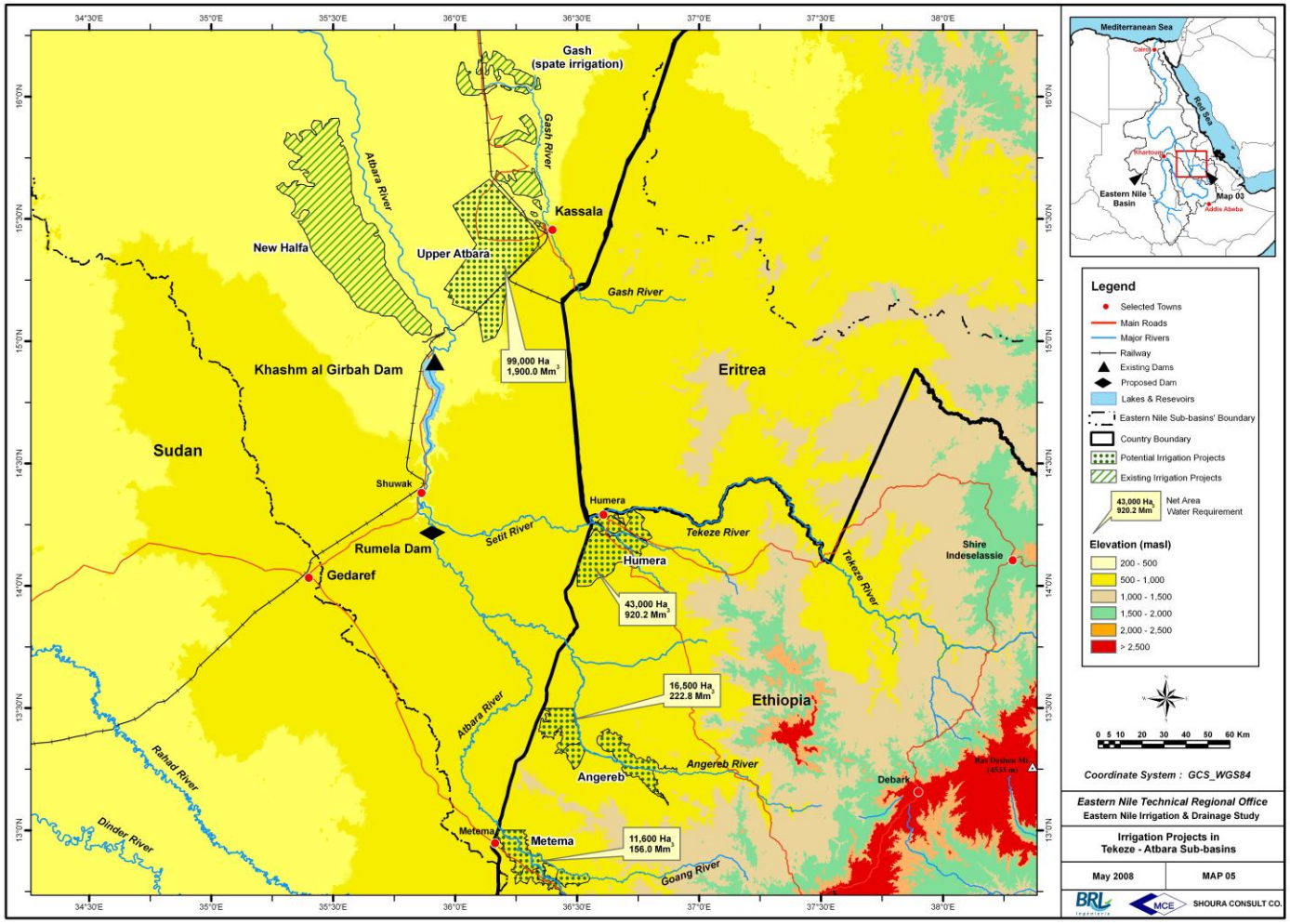
Table 15: Irrigation projects in Tekeze Atbara sub-basin

Name of projects	**Net Area (Ha)**	**Unit water requirement (m^3 /ha/year)**	**Annual water requirement (MCM)**
Ethiopia			
Humera (see note)	60 000	21 400	1 284,0
Angereb	16 540	13 500	223,3
Metema	11 560	13 500	156,1
* Wolkayite	27 040	13 500	365,0
* Small scale irrigation projects	186 860	13 500	2 522,6
Sub-total Ethiopia	*302 000*		*4 551,0*
Sudan			
Upper Atbara	99 000	19 000	1 881,0
Grand total	401 000		6 432,0

Source: Tekeze River Basin Integrated Master plan and Upper Atbara project Feasibility Study (figures for areas were rounded to the nearest hundred of hectare). *Projects not listed in the TOR of the engineering component are not shown on map 04.

Note: In the Tekeze master plan unit water requirements for Humera project is 21,400 m^3/ha. The draft feasibility study (Water Work Supervision and Design Enterprise) indicates a unit crop water requirement of nearly 24,000 m^3/ha. These figures seem overestimated by comparison to water requirement of Angereb and Metema projects. Final feasibility report is not available at the Ministry of Water Resources.

Map 05: IDZ 4: Tekeze – Atbara sub basins *(print pdf map on A4 paper)*



3.2.5 IDZ 5: Baro-Akobo and Sobat sub-basin in Ethiopia and Sudan

This irrigation development zone is a vast flood plain that lies below altitude 1000 m in Ethiopia and Sudan. The region is mainly populated by agro-pastoralists. Arable agriculture is limited to the Eastern areas of Gambela while the rest of the flood plain is used for pastoralist and subsistence agriculture. Population density is low. Gambela region is one of the regions where resettlement program of the Derg government of Ethiopia took place; in addition they have been a large number of refugees settling in Gambela due to the civil war in Sudan. Irrigation is limited to the bank of the White Nile downstream between the confluence with the Sobat and the Jebel Awlia reservoir located some 750 Km downstream of the confluence (and 30 Km upstream of Khartoum).

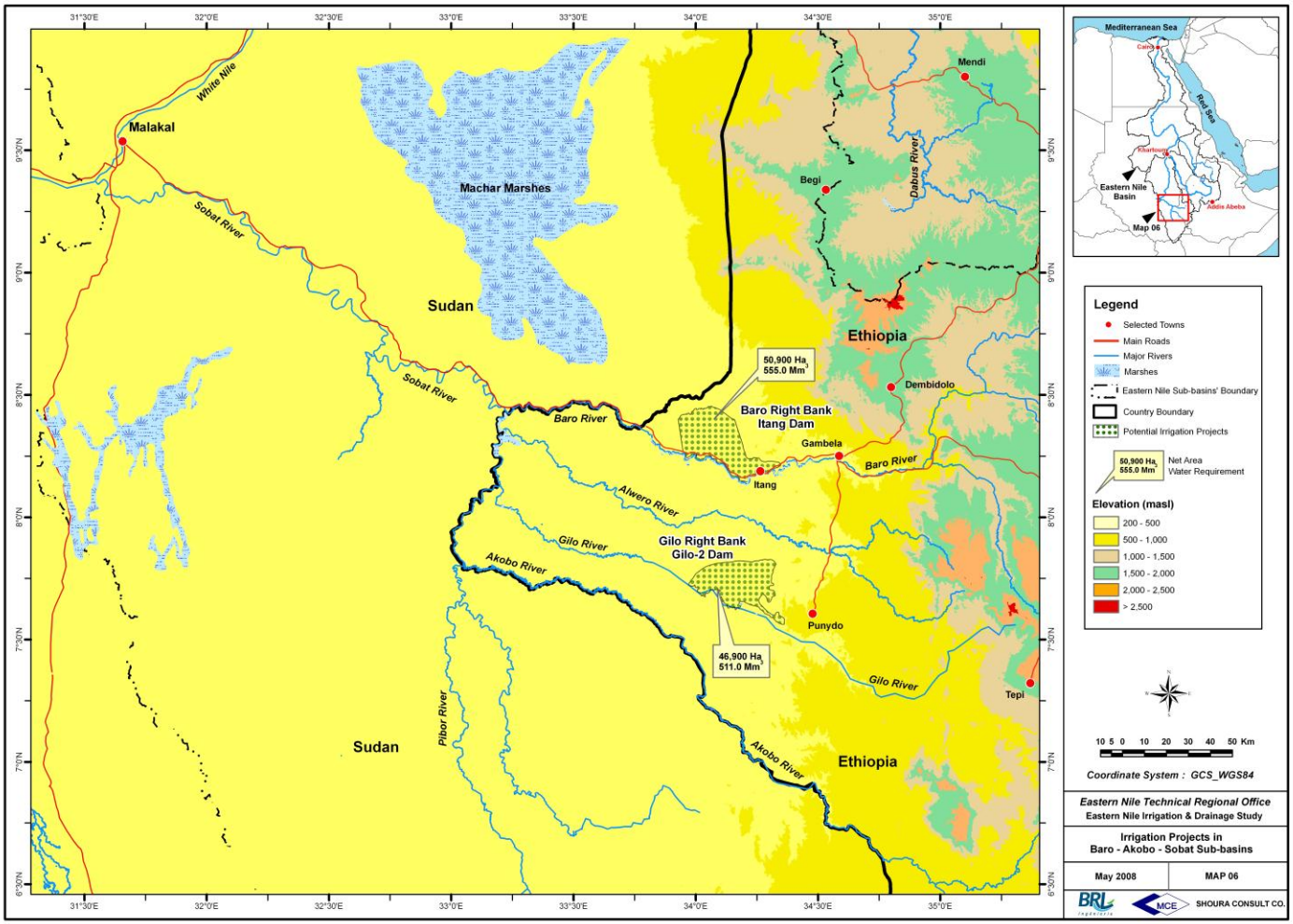
Flooding is the commonest natural problem in the region; it inflicts major damages on crops, livestock and property. According to the Nile Water Study (1978), out of the 20 BCM of water/year from the Baro and Akobo rivers system in Ethiopia, about 14 BCM reach the White Nile through the Sobat River, essentially between September and December. The remaining 6 BCM of water are lost through evaporation in the Machar marshes.

The studies conducted so far had shown that there is a large potential for commercial irrigated agriculture development in the Gambela plain in Ethiopia excluding the western portion of the area which is subject to persistent flooding. Large distance from market and little interest, if any, of local population for irrigation make small scale irrigated farming unfeasible.

According to the Baro-Akobo River Master Plan Study, the irrigation potential of the sub-basin is 483,000 Ha and the annual gross water requirement to fully develop the potential is 6,520 MCM (Unit gross water requirements are estimated at 13,500 m^3/Ha). Irrigation projects areas are: Baro river left and right bank projects, Alvero River project and Gilo river left and right bank projects.

Map 06 shows the Baro River right Bank and the Gilo river right Bank projects that are listed in the TOR of the engineering Component of the present study.

Map 06: IDZ 5: Baro-Akobo sub-basin *(print pdf map on A4 paper)*



3.2.6 IDZ 6 & 7: The Nile in Egypt

Egypt has planned to add 1,117,200 hectares (2.66 million feddans) of new irrigated land by the year 2017. This will be done through several large projects: El Salam Canal project in the East Delta; reclamation of land west of the Delta and the Sinai; and the Tushka project in the South of the Nile Valley. The total irrigation water requirements of irrigation expansion are approx 20 BCM. Maps 06 & 7 show the location of irrigation expansion projects in Egypt.

El-Salam Canal, East Delta and Sinai.

The project wants to develop a total irrigated area of 260,000 hectares (620,000 feddans). The first stage consists in developing 92,400 hectares (220,000 feddans) between the Eastern Damietta branch of the Nile and the Suez Canal and the second stage will develop 168,000 hectares (400,000 feddans) in the Sinai Region.

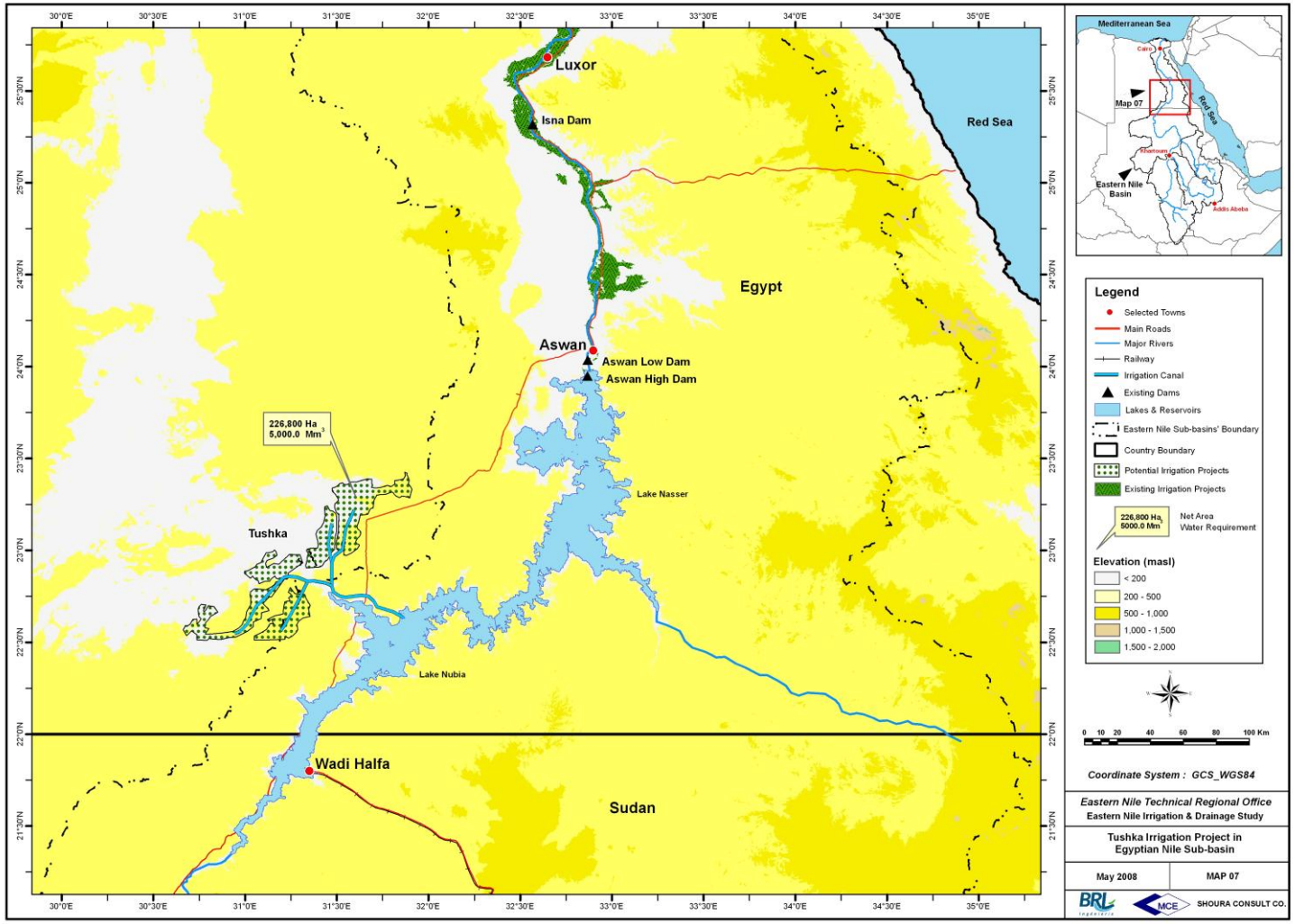
The annual water requirement of the two stages of the project was estimated at 4.5 BCM of which 2.2 BCM will be pumped form the Damietta branch of the Nile and 2.3 BCM from the drainage system (El-Serw and Hadus drains). Nile and drainage waters will be blended to obtain irrigation water with an acceptable salinity level of 700 to 825 ppm.

The first stage of the project was completed in 1995, main features are:

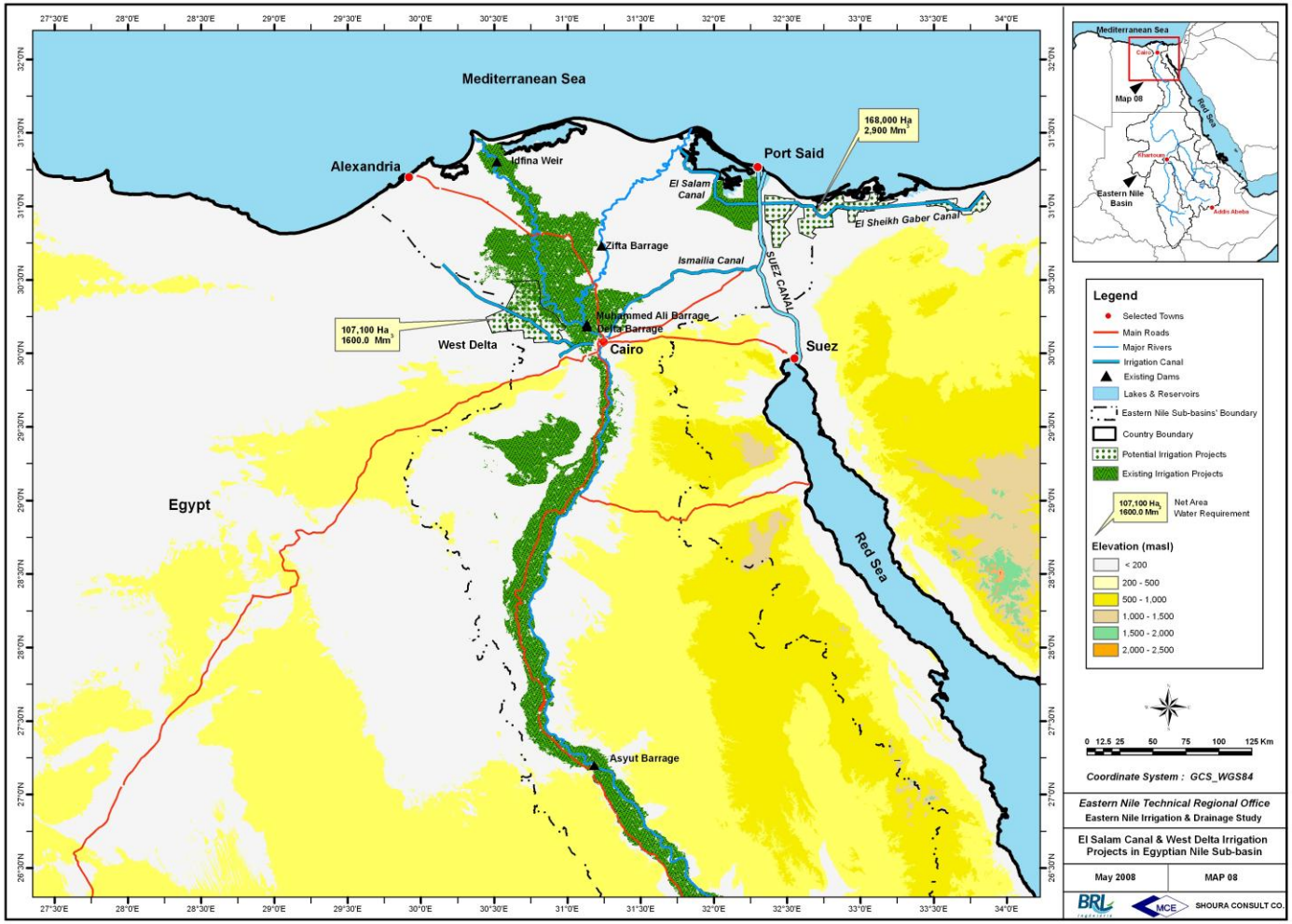
- Three pumping stations on the Damietta branch of the Delta and the drainage system;
- Construction of El Salam canal from Damietta branch to Suez canal (length: 87 Km) and appurtenant work: head regulators to control water distribution among the branches of the canal, siphons and bridges crossing roads and natural water ways;
- Main features of the second phase to be completed by 2017 are:
- Construction of a siphon below the Suez Canal (completed);
- Construction of the 175 Km long El Sheikh Gaber El Sabbah Canal and its appurtenant works: four pumping stations and four regulators for water distribution (ongoing);
- Reclamation of 400,000 feddans of land, which are sedimentary formation of ancient Nile branches in the Sinai, East of the Old Delta (ongoing).

The second stage of the project is under implementation and irrigated agriculture projects are already under operation in the Sinai Region.

Map 07: IDZ 6: The Nile Valley in Egypt *(print pdf map on A4 paper)*



Map 8: IDZ 7: the Nile Delta in Egypt *(print pdf map on A4 paper)*



The West Delta project

The Government has identified an initial area of 107,000 hectares (255,000 feddans) in the West Delta for private sector investment in irrigated farming. Main features of the West Delta project are as follow:

- Pumping of 1.6 BCM per year from the Rosetta branch of the Nile into Nasseri Rayah and from three sites along this canal into the project area;
- The construction of the water conveyance infrastructure (open canals or pipes) and
- Distribution of the surface water to individual farms or blocks of farms of an area of 42 hectares (100 feddans) or above.

The Tushka project in Upper Egypt

This mega project is the largest project in the country since the construction of the High Aswan Dam. It consists in creating a "second Nile valley" in Upper Egypt. Key features of the project are: (1) Construction of a pumping station on the left bank of lake Nasser near Khor[12] Tushka, (2) construction of a 70 Km long lined main canal (Sheikh Zayed canal) ant its four branches, (3) equipment and irrigation of 227,000 hectares of desert land split into four areas and (4) population resettlement, industry, roads and communication and the associated social services. Total annual water requirement of the project was estimated at 5 BCM.

Table 16: Area and water requirement of irrigation expansion projects in Egypt

IDZ	Projects	Net Area (Ha)	Unit water requirement (m^3 /ha/year)	Annual water requirement (MCM)
IDZ 6	Tushka	226,800	22,000	4,990
IDZ 6	* Upper Egypt and South Valley development	431,760	18,830	8,130
Total IDZ 6		658,560		13,120
IDZ 7	El Salam canal (phase 2)	168,000	17,300	2,906
IDZ 7	West Delta Project	107,100	15,000	1,607
IDZ 7	North Sinai Development	105,000	14,290	1,500
IDZ 7	West Delta and Northern Development	78,540	11,970	940
Total IDZ 7		458,640		6,953
GRAND TOTAL		**1,117,200**		**20,073**

Source: Communication of the Egyptian Ministry of Irrigation and Water Resources to the consultant. * Not shown on map 07.

[12] Khor: Arabic word for seasonal stream.

3.3 CHALLENGES RELATED TO AVAILABILITY AND RELIABILITY OF WATER SUPPLY

Each Eastern Nile country has ambitious plan for developing its irrigation sector. As a result major challenges relate to water supply availability and reliability.

3.3.1 Water availability: Current water utilization and future plans

Egypt

The Nile in Egypt is a closed basin: There is no excess water at any time of the year. This case represents a zero-sum game in physical terms; additional use of water by one category of users means reduced use by other users and reduced environmental flow. This is well illustrated in table 17 showing water balance in 1997 and projected water balance in 2017 according to Egypt's National Water Resources Plan (1197 – 2017).

Table 17: Water balance in Egypt.

years	1997			2017 (projected)		
Inputs & outputs in BCM/year	**Supply**	**Demand**	**Consumed**	**Supply**	**Demand**	**Consumed**
Evaporation losses from Lake Nasser			10.0 – 14.0*			10.0 – 14.0*
Release from Aswan	55.5			55.5		
Effective rainfall	1.3			1.3		
Agriculture		57.8	39.3		63.6	41.9
Industry		7.5	0.7		18.7	0.9
Municipal		4.7	0.9		6.6	1.6
Fisheries		1.3	0.4		0.6	0.2
Navigation		0.2	(0.2)**		0.2	(0.2)**
Open surface evaporation			2.4			2.5
Outflow to sea			13.1			9.7
Total	56.8	71.5	66.8 – 71.8	56.8	89.7	66.8 – 71.8

Source: Egypt National Water Resources Plan 1997 – 2017 * According to estimates from several studies
** Included in "Outflow to sea".

Water demand is the water diverted for a particular use. Consumed water is the fraction of diverted water which is definitely lost by the system; it corresponds to evaporation, evapotranspiration and water flowing to sea and deserts. The difference between water demand and consumed water is the amount of recycled water within the system such as drainage water reuse, renewable groundwater abstraction (seepage from the Nile) and treated waste water reuse.

To cope with increasing water demand, annual outflow to the sea will be reduced by 26% from 13.1 to 9.7 BCM. In Egypt, outflow to the sea has several functions: diluting polluted water, controlling salinity intrusion, and sustaining coastal ecosystems. These functions might have been overlooked in the National Plan which does not make any mention of environmental flow requirements.

Secondly, the amount of water diverted for irrigation per Ha will decrease of approx 20% Since Egypt National Water Resources Plan envisages an increase of the irrigated area from 3.5 to 4.6 million Ha. This would be achieved by minimizing the production of high water consuming crops such as rice and sugar cane. However there is a risk that yields and cropping intensity drop if day to day on-farm water supply becomes too stretched. The million of Egyptian small scale farmers in the old lands may also become very reluctant to pay for O&M if they find the water service unsatisfactory.

Finally the system will reach its limits after (or even during) the completion of the Plan. Further adaptations would require re-allocation of water from agriculture to municipal and industrial uses.

Sudan

- ***The Nile basin in Sudan is a closing basin:*** There is lack of water during the low flow season and excess water during the high flow season. The results are lack of sufficient water to supply its irrigation schemes over the year, damages from flood and sedimentation of its reservoirs and its irrigation systems. In other words, Sudan faces the same problems that Egypt confronted before the construction of the High Aswan Dam. Thus storing water and reallocating it between seasons can achieve potentially large increase in the value of water. In an unilaterally manner, envisaged solutions are the construction of new dams in the Atbara sub-basin (Rumela and Setit dam in IDZ 4) and heightening of the Roseires dam with a view to use the country's full share of Nile waters as per the 1959 Agreement. The total Nile water available to Sudan is 18.5 BCM measured at Aswan as per the Nile water agreement of 1959; this equivalent to 20.5 BCM measured at Sennar. Present use of Nile water is approx 17 BCM of which 15 BCM for irrigation[13]. Obviously it would be impossible to meet the additional 12 BCM water demand for planned expansion projects. Sudan will have to prioritize irrigation expansion projects and more importantly take measures for improving water use efficiency in existing irrigation schemes to allow irrigation expansion.

Ethiopia

- ***The Abbay, Tekeze and Baro - Akobo basins in Ethiopia are open basins:*** They have excess of water over all committed requirements at any time of the year; Ethiopia has no water sharing agreement with other riparian countries. The excess water has no opportunity costs and all what is needed is considering the costs of utilizing more of the water relative to the benefits of doing so. After decades of civil troubles, Ethiopia is now in a much favourable situation for developing its water resources. For the irrigation sector, the National Water Resource Management Policy aims "to develop the huge irrigation potential for the production of food and raw materials needed for agro-industries…" The Nile water resources in Ethiopia are virtually untapped. The total water requirement of the proposed projects in the Eastern Nile basin in Ethiopia is 17 BCM. Due to the high seasonal and annual variability of flow in the river systems, Ethiopian irrigation expansion projects are dam dependent except for the few projects that would use the regulated water of Lake Tana. However the Abbay River is a huge potential for hydropower and pre-feasibility studies for the construction of four hydropower dams on the Abbay River were done during the Abay Basin Master plan study. This should be considered when negotiating a water sharing agreement at the Basin level. Ethiopia is the water tower of the Eastern Nile and at country level; water availability is not a burning issue. However in the framework of regional cooperation, irrigation development in Ethiopia would have to consider the issue of water availability / scarcity in downstream countries; here again a water sharing agreement between the three countries will be a strong incentive for Ethiopia to pay the highest attention to irrigation water use efficiency, the possibilities of conjunctive use of surface and ground water and to the return of excess rain and irrigation water to the river system through effective drainage. Nonetheless, this is well in line with Ethiopia irrigation development strategy which wants to improve irrigation water use efficiency. Experience and strong expertise of Egypt in water saving technologies and practices could be of great help for Ethiopia.

[13] Source: Ministry of Irrigation and Water Resources; Country Strategy on Integrated Water Resources Management (2007).

At basin level

- ***The Eastern Nile basin is a closing basin***. Generally in a closing basin, excess water in the high flow season goes to "sinks", usually a sea. But in the case of the Eastern Nile there is no excessive water flowing to the Mediterranean Sea due to high water use efficiency in Egypt. Excess water of the Eastern Nile is lost through evaporation in reservoirs in Sudan and Lake Nasser (table 18) and in the river system itself when large areas are flooded and in the swamp area of southern Sudan. The best way of storing high flow water and reallocating it during the low flow season is the construction of dams in the upstream part of the basin in Ethiopia (see § 3.3.2) where cooler temperatures and shape of the valleys (deep and narrow gorges) would minimize evaporation losses. Water conservancy projects draining part of the water which is lost by evaporation in the gigantic swamps in the South of Sudan could increase the amount of water available for irrigation and other uses by 4 to 5 BCM (see § 3.3.3). Implementation of these projects is unlikely in the near future for a set of political, social and environmental reasons.

Table 18 Evaporation losses from dam reservoirs

Country	Dams (sub-basins)	Evaporation losses (BCM/year)
Egypt		
	High Aswan Dam (Main Nile)	10.00 – 14.00
Sudan		
	Roseires (Blue Nile)	0.33
	Sennar (Blue Nile)	0.58
	Merawi (Main Nile)	n.a
	Jebel Awlia (White Nile)	3.45
	Khashm El Girba (Atbara)	0.12
Total		**14.5 – 18.5**

Information on evaporation from the Marawi dam reservoir is not available.

- Obviously it will not be possible to meet demand of all the existing and planned irrigation projects let alone other water uses (table 19). There is a pressing need for enhanced regional cooperation to adopt a more integrated approach of the Eastern Nile waters utilization rather than continuing with unilateral planning. Reaching an agreement on sharing waters of the Eastern Nile basin accompanied by the necessary institutions and mechanisms for enforcement and monitoring may well be the foundation of such enhanced cooperation.

Table 19: Irrigated area and irrigation water requirements in the Eastern Nile

Country	Egypt	Ethiopia	Sudan	Total
Current irrigation water requirement (BCM)	58.0	0.7	15.0	73.7
Existing irrigated area (million Ha)	3.5	0.1	1.9	5.5
Water requirements of the planned irrigation expansion project (BCM)	20.0	17.1	12.0	49.1
Planned irrigation expansion projects (million Ha)	1.1	1.5	1.2	3.8
Projected irrigation water requirement after expansion (BCM)	78.1	17.8	27.0	122.9
Projected irrigated area after expansion (million Ha)	4.6	1.6	3.1	9.3

- So far, irrigation development planning was done at country level through basin master plans or water sector studies that paid very little if any attention to upstream and downstream impacts or, in other words, each country has so far envisaged irrigation development in a unilaterally manner. Egypt and Sudan irrigation development policies / strategies refer to the 1959 Nile Water Agreement between both countries. This agreement mentions that additional water from conservancy projects will be shared equally between Sudan and Egypt. However it does not say anything about reduction of the amount of available water due to increased water use in Ethiopia. More generally future water developments in the Eastern Nile are likely to make the 1959, which ignores Ethiopia, outdated and no longer applicable. The three countries, through the NBI, are already working addressing this important issue. It is envisaged to reach a new agreement that satisfies all riparian countries.

- Further irrigation expansion depends on future water development: Water storage in Ethiopia and the unlikely conservancy projects which should be accompanied by the (re)definition of water entitlements, or "rights" on the Eastern Nile waters. Water allocation among users at country, sector, irrigation systems and farm level must be negotiated, made transparent and enforced technically and legally. The best option might be to build consensual water allocation patterns by negotiation under the umbrella of a future Eastern Nile basin organization or a well orchestrated institutional development between national public agencies in charge of water resources and irrigation. This issue is further addressed in the institutional analysis of the present report. This is in line with the "Shared Vision" of the Nile Basin Initiative. It will take time to establish enforceable water rights and a complementary set of institutions at basin, country and irrigation system levels. The task is monumental as are the challenges ahead for the Nile Basin Initiative and supporting Subsidiary Action Programmes.

3.3.2 Reliability of water supply

Waters of the Eastern Nile basin originate in the rainfall over Ethiopia which mostly occurs between July and September. As a consequence river natural flows present a high seasonal variability. Moreover, rainfall in Ethiopia also shows high annual variability with alternative years of flooding and drought. As an illustration, table 20 presents the variation in the flow of the Nile at the Ethiopia-Sudan border. At present there is no infrastructure (dam) in the Abay basin for over year or seasonal storage and flow regulation.

Table 20: mean, maximum and minimum flow (m^3/second) of the Blue Nile at Ethiopia-Sudan border (since 1960)

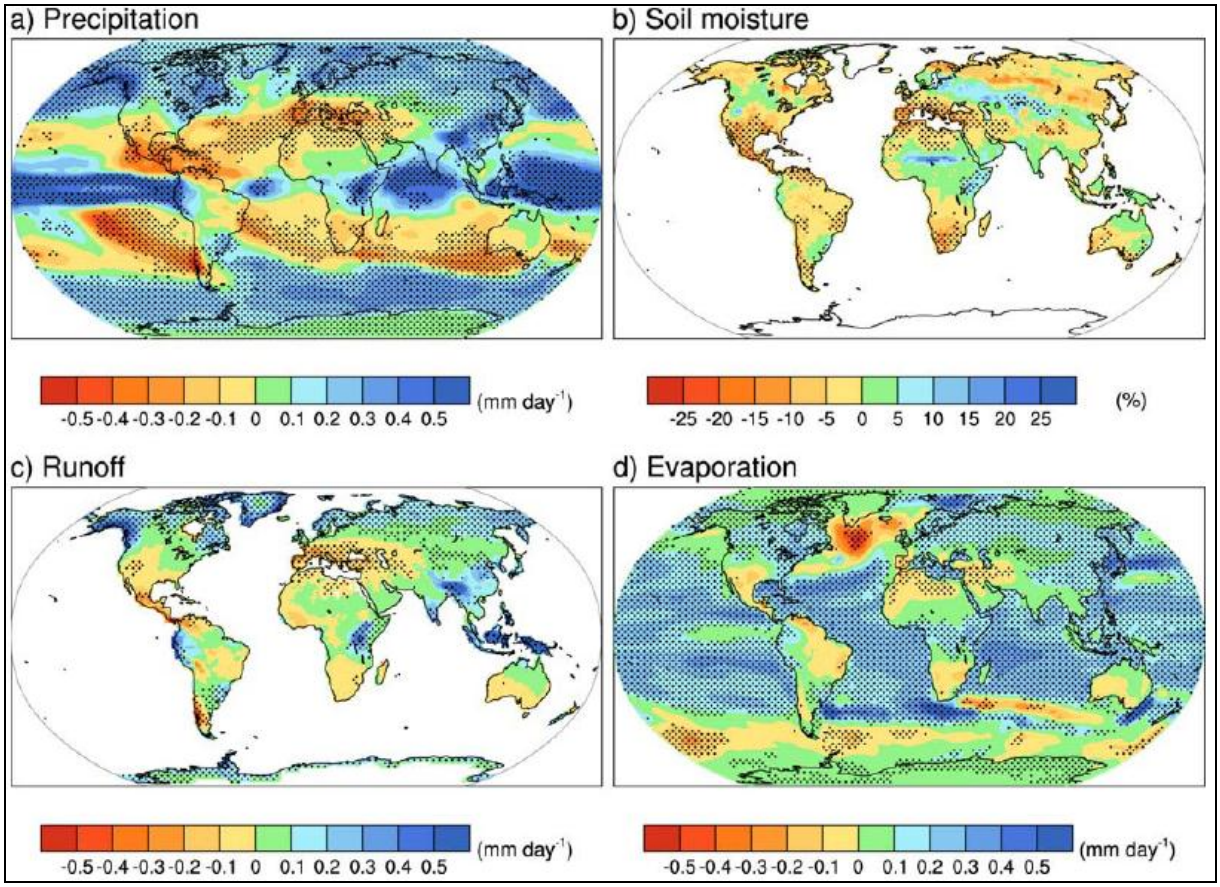
	Mean	Max	Min
Jan	345	527	212
Feb	229	434	137
Mar	162	306	93
Apr	141	194	81
May	240	470	99
Jun	722	1,453	472
July	2,841	6,018	1,930
Aug	5,634	6,988	3,693
Sep	4,340	5,919	2,813
Oct	2,468	3,708	1,306
Nov	1,019	1,551	681
Dec	526	755	324
Year	1,556	2,360	987

Source: ENTRO Eastern Nile Power Trade Study.

3.3.3 Forecasts of climate change

Forecasts of climate change in Ethiopia indicate that global warming or elevation of temperature will increase crop evapotranspiration by 0.2 to 0.3 mm/day. Total annual precipitation will increase by 0.3 to 0.5 mm/day, the increased variability of rainfall events and increased frequency of extreme events, drought and rainstorm will increase the volatility of rain-fed production. Higher rainfall intensity may damage crops and increase soil erosion. Combination of higher precipitation and increased variability of rainfall will increase water management complexity. In the Nile basin, runoff which integrates a complex set of parameters: rainfall, topography, evaporation, evapotranspiration and soil water storage will increase by 0.3 to 0.4 mm /day.

Figure 9: Prevision of changes in a) precipitation (mm day–1), b) soil moisture content (%), c) runoff (mm day–1), and d) evaporation (mm day–1). Changes are annual means for the period 2080–2099 relative to 1980–1999.



Source: FAO Synthesis Paper based on an Expert Meeting held in Rome from the 26th and 28th of February, 2008 as a preparation for the FAO High Level Conference (HLC) on World Food Security and the Challenges of Climate Change and Bio-energy in June 2008.

The Abbay River basin has an area of 196,700 Km^2 and the mean current annual runoff is 52.6 BCM; equivalent to 2.4 mm/day. An increased runoff between 0.3 and 0.4 mm represents and increase between 13% and 17%. This means that according to the above prediction the annual runoff will reach between 59.4 and 61.5 BCM/year in the period 2080 -2099.

Another forecasted impact of climate change is rising of the Mediterranean Sea level by 0.50 m by 2100. This will exacerbate the challenges already faced by Egypt: Loss of agricultural land and increasing soil and water salinity in the Delta.

3.4 OPPORTUNITIES RELATED TO AVAILABILITY AND RELIABILITY OF WATER SUPPLY

3.4.1 Water supply augmentation and increased reliability through water storage in Ethiopia

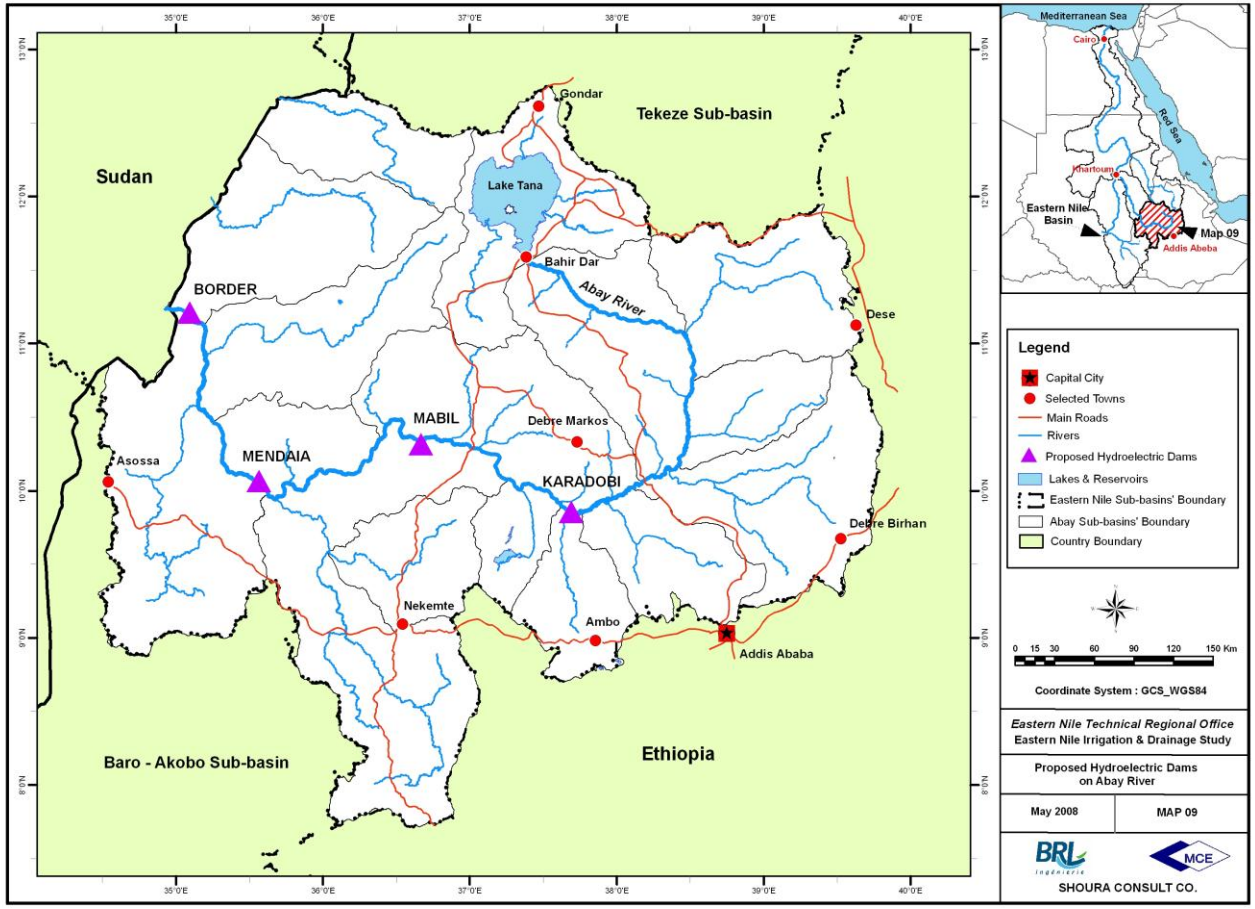
The Blue Nile Basin Study Plan (USBR 1964) and Abbay Basin Master Plan (BCEOM 1999) include preliminary designs of four dams for hydropower along the Ethiopian Blue Nile. The Karadobi Dam and reservoir would be located just upstream of the Guder River confluence, approximately 385 km downstream of Lake Tana, and would be responsible for controlling a draining area of nearly 60,300 square kilometres. The Mabil Dam would sit 145 km further downstream, 25 km downstream of the confluence with the Birr River. The Mendaia and Border Dams would be constructed about 175 km and 21 km upstream of the Sudan-Ethiopian border, respectively. Further dam details and characteristics are given in appendix 2. Location and characteristics of the dams may be modified by ongoing feasibility studies. The four dams would have a total water storage capacity of 73.1 BCM, which is equivalent to approximately 1.5 times the average annual runoff of the Blue Nile at the Sudanese border. The total capacity would be 5,570 megawatts. This would be a tremendous increase of the existing installed electric power within Ethiopia[14]. Construction of the dams would also have many advantages for the downstream countries. These advantages are mainly:

- Flow regulation that would provide Sudan with ability to irrigate large areas in the cold season when the Blue Nile flow is naturally low;
- Reducing the areas inundated by flow peaks in Sudan and water losses through evaporation in the river system;
- Reducing sedimentation in Roseires and Marawi dams in Sudan;
- Reducing the need for water storage in Roseires and Marawi dam thus saving water through reduction of evaporation losses;
- Increasing hydropower production in Roseires and Marawi dams through much increased flow during the dry season;
- Reducing the need for storage at Aswan and thus saving considerable amounts of water through reduction of evaporation losses. At present evaporation losses from Lake Nasser are in the range of 10 to 14 BCM per year depending on the lake level;
- Reducing sedimentation in Lake Nasser.

Maximizing the above advantages demands new agreements between countries regarding costs and benefits sharing mechanisms, patterns of governance and operation rules, which are acceptable to all countries. Joint or coordinated management of future Ethiopian dams and the already existing dams on the Eastern Nile implies either a basin level institution or effective cooperation mechanisms between the national institutions in charge of water resource management. This is addressed in more details by the Institutional Analysis. Additional studies are greatly needed for defining objectives, responsibilities, duties, structure and operation rules and financial requirements of the basin level agency or the cooperation mechanisms. Ongoing feasibility studies of the Ethiopian dams focus on hydropower production only. We recommend carrying out more comprehensive studies on potential costs and benefits of regulated water in the Eastern Nile basin. Another important issue to be considered is the software technology such as communication systems and supervisory control and data acquisition (SCADA) in the river system that will be necessary for optimizing the water flow under any natural hydrological circumstances.

[14] Present installed electric power in Ethiopia is 800 megawatts.

Map 09: Hydropower dam projects in Ethiopia *(print pdf map on A4 paper)*



3.4.2 Joint irrigation investment projects

The two transboundary irrigation development zones (IDZ) also offer opportunities for augmentation and increased reliability of water supply. The concerned zones are IDZ 3: Blue Nile and Rahad, Dinder tributaries in Ethiopia and Sudan (see map page 44) and IDZ 4: Tekeze and Atbara sub-basins (see map page 46).

In IDZ 3, concerned projects are Rahad (45,100 Ha) and Galegu (9,900 Ha) projects dependent on a dam across Rahad river, and Lower Dinder irrigation project (50,000 Ha) dependant on a dam across Dinder River in Ethiopia, Rahad 2 project (210,000 Ha) in Sudan, it is planned that Rahad 2 project will harvest Dinder and Rahad rivers water through construction of a dam across each river and through a link canal joining Dinder and Rahad rivers to complement Blue Nile waters diverted from the Roseires dam. Naturally, development of irrigation upstream in Ethiopia would reduce water available for Rahad 2 project as presented in table 21.

Table 21: Rough calculation of water availability in Rahad and Dinder rivers.

	Rahad R	Dinder R
Current annual flow to Sudan (Mm^3)	1,000	2,200
Water requirement of Rahad project, Ethiopia (Mm^3)	501	
Water requirement of Galegu project, Ethiopia (Mm^3)	106	
Water requirement of Lower Dinder project, Ethiopia (Mm^3)		560
Annual flow to Sudan after completion (Mm^3)	393	1,640

*Source: Sudan Ministry of Irrigation and Water Resource, Rahad phase 2 project, pre-investment technical and economic study (August 2000).

In IDZ 4, concerned projects are Humera (43,000 Ha) dependant on a dam across the Tekeze River or Setit River in Sudan Angereb (16,500 Ha) dependant on a dam across Angereb River a tributary of Atbara River and Metema (11,600 Ha) dependant on a dam across Goang River (Atbara River in Sudan) in Ethiopia, Upper Atbara project (99,000 Ha) and existing New Halfa project (180,000 Ha) both on Atbara River in Sudan. The Upper Atbara project includes the construction of two dams, first the Rumela dam on Atbara river just upstream of the confluence with the Setit river and at a later stage a dam on the Setit river to supply water for the new irrigation scheme and also to the New Halfa scheme as Khashm El Girba dam is now almost silted up.

Table 23: Rough calculation of water availability in Tekeze-Atbara sub-basin.

	From Angereb,Goang ,Atbara R	From Tekeze Setit R	Total
Current annual flow in Shuwak, Sudan (MCM)*	5 000	7 500	12 500
Water requirement Humera project (MCM)		920	
Water requirement Angereb project (MCM)	223		
Water requirement Metema project (MCM)	107		
Annual flow in Shuwak, Sudan after Ethiopian projects completion (MCM)	4 670	6 580	11 250

* Source Upper Atbara feasibility study

At a reduced scale, IDZ 3 and IDZ 4 present the same challenge on water availability as in the entire Eastern Nile system. A feasibility study for joint (transboundary) irrigation development projects would determine the "best bet" option regarding costs and benefits of irrigation projects. It could also identify economy of scale in terms of water storage infrastructure, for instance with water storage upstream in Ethiopia, water storage needs in Sudan would be reduced and in terms of processing and marketing, for instance part of the production of the Ethiopian schemes (located at Ethiopia – Sudan border) could be processed and marketed in Sudan or exported at Port Sudan. More generally a feasibility study of transboundary irrigation development projects would also determine mechanisms of regional cooperation regarding water management and dam operation, research and extension services and capacity building activities for irrigation staff and farmers organizations; hence transboundary irrigation development projects would serve as a test "in the real world" for processes and levels of cooperation at the Eastern Nile basin level. A project profile for transboundary irrigation development project is presented in part V of this report.

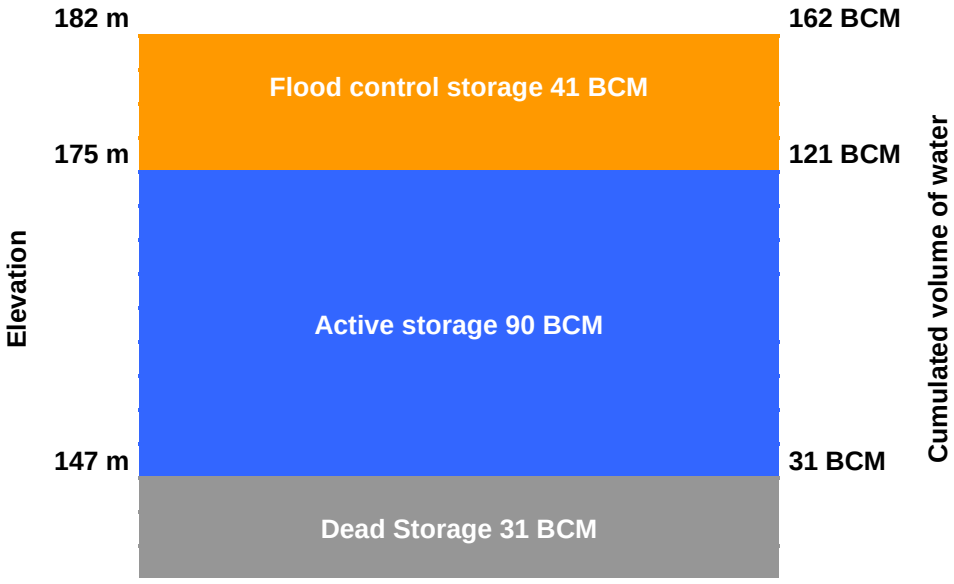
3.4.3 Optimizing dam operation dam operation

The Jebel Awlia dam

The Jebel Awlia dam is located on the White Nile approx 30 Km upstream of Khartoum. It was built in 1937 to supply water to Egypt during the low-flow summer months, but since the completion of the High Aswan Dam in 1971, it is no longer needed for this purpose. Today, the level of Jebel Awlia reservoir is maintained to reduce the pumping costs of the White Nile pump schemes, this brings about approx 3.5 BCM of water losses through evaporation from the reservoir. Lowering water level of the reservoir of the dam is a possible option for saving water but it would increase pumping costs of the White Nile pump schemes. Further studies are needed to determine the costs and benefits of this option.

The High Aswan dam

Figure 10: Main features of the High Aswan dam.



- The dead storage capacity (31 BCM) was designed as a silt trap for about 500 years. Elevation 147 m is the minimum design water level for operating the hydro-electric power station.

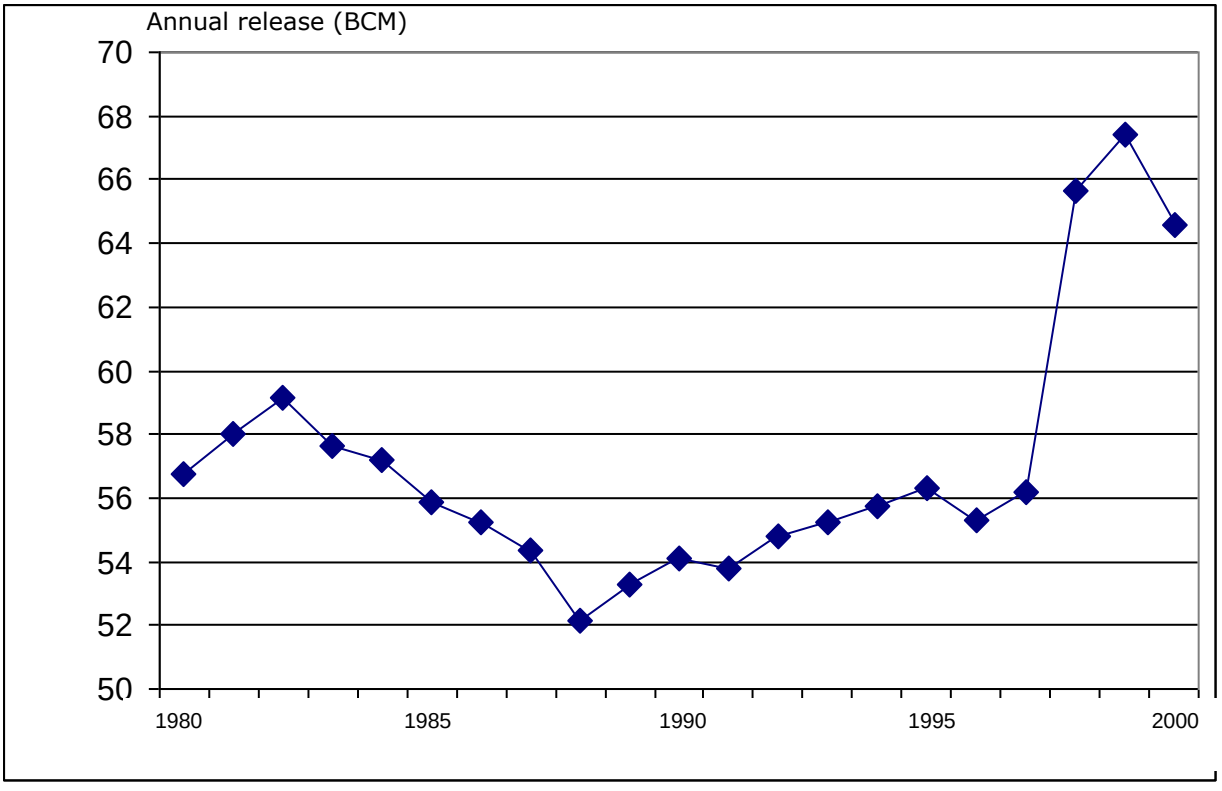
- The active storage capacity was designed based on the average annual Nile flow over the period 1901/02 – 1953/54 (84 BCM). The necessary live storage capacity was calculated to be 90 BCM.

- The flood control capacity (41 BCM) was designed to store the water of high flood years. Before the arrival of the flood in August, the maximum water level should be 175 m. The Tushka spillway was executed in 1982 to protect the Nile channels and barrages downstream of the High Aswan dam from release of aggressive high discharges.

The present operation of the High Aswan dam is based on a fixed annual release of 55.5 BCM pursuant to the 1959 Agreement. However the annual Nile supply at Aswan varies considerably from one year to another; over the period 1870 – 2000, the record low was 42 BCM in 1913/14 and the record high 150 BCM in 1878/79. An alternative dam operation would be a variable annual release depending on the reservoir level. Larger releases at high level would (i) increase water availability, (ii) reduce evaporation losses by lowering Lake Nasser level and (iii) reduce the spill to the Tushka depression. At low reservoir level, the release should be reduced. In practice annual releases are already variable (figure 11). In high flood year, Egypt has no choice but to release or spill water in excess of 55.5 BCM for the safety of the dam (figure 11, period 1998 – 2000). Shifting to a variable annual release downstream of Aswan requires:

1) A revision of the 1959 agreement;
2) Increased knowledge of the Nile hydrological cycle;
3) Increased technical capacity to vary annual water allocation to users;
4) New institutional mechanisms to adjust allocated water with variable releases at Aswan.

Figure 11: Annual releases from the High Aswan dam, 1980 – 2000.



3.4.4 Water conservancy projects in the Eastern Nile

The possibilities for water conservancy projects are in Sudan where about 50 BCM of water evaporate every year in the swamps. However the wetlands provide important environmental benefits and sustain the production systems of the local population. Impacts of projects on environment and livelihood of concerned population must be carefully assessed. Furthermore cooperation of local population is an essential condition of projects implementation. This implies they must have a full knowledge and understanding of the projects including their share of the benefits. Two possible conservancy projects have been identified since many years:

- *Completion of the Jonglei canal*: The Jonglei canal project involves a 300 km long canal between the confluence of the Sobat River and the White Nile near the town of Malakal and the village of Bor on the Bahr al Jabal thereby diverting the water entering the Sudd, a gigantic swamp where 50% of the water is lost through evaporation. The comments hereafter are based upon communication between the consultant and French engineers who were involved in the Jonglei canal project between 1978 and 1983. The initial design was made one century ago and modified in 1980. The canal is designed to divert up to 30 MCM per day as far as the White Nile level at the intake allows it. A dam controlling across the White Nile for controlling the water level would give the possibility of using the canal at its full capacity at any time. The canal is also designed for navigation, which is important for the local economy, and it offers opportunities for irrigation along its banks in the dry season. Over 250 Km were excavated in 1983 when the SPLA stopped the work. Table 23 is a very rough evaluation of the costs of works for completing the Jonglei canal, including a Nile dam. Annual water saving was estimated at 6 BCM. For the part reaching Aswan, a loss of 20% would be likely, thus final annual saving would be in the range of 4.8 BCM. The investments cost per saved BCM would be in the range of US$ 115. Potential benefits are reduction of risks of conflict over water, increase of hydropower production at Marawi and Aswan through increased Nile flow during the dry season and irrigation. Acceptance by the local population is the main challenge of the implementation of the Jonglei canal project; this demands careful investigation on its impact on livelihood, local culture and environment and a fully informed participation of the local population in its preparation and implementation. Conditions to implement this project are unlikely to be met in the foreseeable future.

Table 23: Rough estimation of costs for complementation of the Jonglei canal.

Description	Cost (million USD)
Dam across the White Nile	50
Excavation including connection to the Nile: 25 MCM x 5 US dollar	125
Structures along the canal	50
Upgrading existing excavated part	25
Sub-Total	250
Contingencies (20%)	50
Total	550

- *Sobat and Machar marshes*: According to the Nile Water Study (1978), about 14 BCM of water evaporates from the Machar Marshes. Many conservations projects were envisaged utilize water from the marshes to supplement the White Nile, namely: (1) reservoirs in Ethiopia for supplying constant flow thus reducing losses and eliminating floods; and (2) direct link for most of the Sobat water from the Ethiopian border to the White Nile at Melut (200 Km North of Malakal) collecting on its way the flows of the smaller rivers. To determine whether engineering works to drain water from the marshes are feasible, one needs to know whether the majority of the water in the marshes comes from rainfall or from river spills. If most of the water comes from channel spills then engineering works such as rising river banks, river dredging and upstream reservoirs to prevent water from spilling into the marshes are feasible. But if water comes largely from rainfall, much more complex and costly works would be needed as the marshes would have to be drained and water to be pumped into the Sobat. Investments costs, water saving potential as well as impacts on local livelihood and environment need to be carefully assessed.

3.4.5 Improving irrigation efficiency and water productivity

Egypt
The NBI creates opportunities for agricultural trading between Nile Basin countries and opens the floor for off-farm agriculture and Egyptian agricultural investments in the Nile Basin countries in order to provide food security and economic prosperity in the region. Egypt can consequently concentrate on cash crops, industry and tourism which have higher economic revenue with less water consumption. It is worth saying here that Egypt is the second importer of wheat in the world and that it imports more than half of its food requirement. Therefore Egypt already relies on economic sectors other than agriculture for its food security.

Sudan
Sudan has a legacy of ageing irrigation infrastructures and technical and managerial difficulties. Productivity of existing irrigation schemes remains low and has not allowed capital accumulation by irrigating farmers' households. Based on this and the increasingly constrained water resources, the focus should thus be more on investment for improving the productivity and water use efficiency in existing schemes rather than new irrigation development. The policy focus should be on using water better rather than using more water through improving farmers' access to improved agricultural technology packages and managerial changes.
However, under present conditions, it is difficult for Sudan to intensify or modernize farming practices in large public irrigation schemes served by the Blue Nile or the Atbara River due to sedimentation in dams and irrigation schemes and an inability to regulate river flows in order to provide reliable irrigation water supplies during the low flow season.

Ethiopia
Irrigation is very little developed in the Eastern in Ethiopia and the country has entered the era of construction of reservoirs and irrigation canals since the last decade. The most important issues coming up in the country relate to institutions and design.
Institutions: There are signs that irrigated area may be growing faster than the institutions needed for ensuring productivity and long term sustainability of irrigation; i.e. irrigation management organizations, agricultural research and extension services, marketing organizations, etc.
Design and technology: Prerequisites for sound irrigation water management, definition of water rights and O&M cost recovery are steady, predictable and measurable flows in the distribution system. These conditions are not met in most of the existing irrigation systems in Ethiopia.

3.5 CHALLENGE AND OPPORTUNITIES RELATED TO IRRIGATION POLICIES.

Obviously, irrigation development is not limited to the construction of reservoirs and irrigation canals. It is accompanied by a set of policy measures aiming at assigning priorities (selection of projects); and at enhancing productivity and securing sustainability of developed irrigation systems. The issue of project selection is discussed in the "Distributive Analysis Report" of the present study; economic viability of projects being the most important selection criteria.

3.5.1 Lessons from the past: Irrigation development in the era of the Green Revolution, 1950 – 1990.

In Ethiopia and Sudan, the overall objective of the irrigation policy is "to develop the huge irrigation potential for the production of food crops and raw materials needed for agro-industries, on efficient and sustainable base and without degrading the fertility of the production fields and water resources base". The first rationale for irrigation development is intensification of agriculture for economic development and poverty alleviation. On the other hand Egypt has already developed its irrigation potential and its agriculture is highly intensified. This was done through implementation of policies over the period 1950 – 1990, characteristics of these policies are given in box 1.

Egypt has followed the model of the Green Revolution which is not only a technical model based on improved crop varieties, agricultural inputs and often but not always mechanization. It is also importantly a set accompanying policy measures based on subsidies to the agricultural sector. A summary of policies followed in Egypt during the Green Revolution period is given in box 1.

Box 1: Summary of policies followed over the period 1950 – 1990 in Egypt

1. Agrarian reforms
2. Investments in irrigation infrastructure: expansion of irrigated area and rehabilitation of existing infrastructures;
3. Development of technology packages including improved crop varieties, fertilizers and pesticides;
4. The presence of a strong irrigation public bureaucracy
5. Public agricultural research centres and extension services at no charge for farmers;

Sudan also followed the Green Revolution model and obtained some success in the 1960's and 1970's but then, a complex set of financial, technical and institutional problems has stopped the process.

In Ethiopia the government launched the Green Revolution (under the name of ADLI[15]). Emphasises were on improved varieties, fertilizers and extension services. The results so far are below expectations. This policy has now been revised toward the development of technology packages adapted to the various agro ecological zones in the country and a greater recognition of the importance of adopting a participatory approach in the dissemination of technology packages.

[15] ADLI: Agriculture Development Led Industrialization.

The Green Revolution because of its immense successes in Asia has been for more than twenty years the ultimate goal of agriculture planners in many developing countries. In the present era of globalization, which started in the 1990's[16], following fully the Green Revolution model is no longer possible. The technology package is still relevant although it can be updated by cutting edge technologies. But accompanying policy measures will have to suit the context of free market economy and intense government budgetary constraints.

Box 2: Definition of the Green Revolution

Historically the Green Revolution in Asia is:
- A set of technology packages for irrigated agriculture in the Asian monsoon regions with use of:
- Improved short stem and high yielding rice and wheat varieties and
- Fertilizers, pesticides, mechanization.

- A set of agricultural policy measures supporting the adoption of technology packages by farmers:
- Guaranteed on market outlets and prices;
- Subsidies to agricultural inputs and farm machinery;
- Farmers' access to credit;
- Protection barriers against imported agricultural products at low price and
- Presence of extension services at no cost for farmers.

The concept of Green Revolution can be enlarged to all types of farming systems (irrigated or rain fed agriculture) or livestock systems:
- Using improved crops varieties or animal breeds;
- Promoting inputs intensive management practices and
- Benefiting of agricultural policy measures reducing risks and increasing farmers' margins at least during the period needed for adoption of the technology packages.

Investment in irrigation usually means public expenditure on new irrigation systems (capital investment). A broader definition is used here to include public investment in other rural infrastructures, irrigation modernization, improved governance, capacity building, management improvement, creation of farmer organizations, and rural credit. In the Eastern Nile countries, financing for major capital works will mostly come from international development banks with varying levels of contribution from national budgets. Each country is experiencing financing packages and incentives to attract private investments. But these investments are likely to be directed toward commercial farms and post harvest (processing & marketing) activities and to not to large capital projects such as dams.

Investments in irrigation by international development banks have declined sharply since the mid 1980's. The main reason put forward was the decline if not "collapse" of world food prices making costs / benefits ratio of irrigation projects unattractive. Reasons for decreasing food prices were attributed to the success of the Green Revolution and to farm subsidies in developed countries combined with dismantling of protection barriers in developing countries**.** Recently the situation has radically changed, world prices of rice, wheat and maize have increased by 280%, 200% and 150% respectively over the period June 2007 – April 2008[17]. In Ethiopia food prices has increased by 40% between June 2007 and May 2008[18]. In Egypt increase of food prices is a major concern for the country economy: Egypt is the second wheat importer in the world and of course for the poor: 40% of the Egyptians live with less than two dollars per day. This dramatic increase of food prices is attributed to (1) increased demand and change in food diet (increased consumption of animal products) with economic development mainly in Asia but this is likely to be also the case of urban consumers in Addis Ababa, Khartoum and Cairo;(2) increasing cropped area for bio fuel production to detriment of food production; and (3) speculation. However increase of food prices makes irrigation investments more attractive.

[16] The Cold War also ended in the 1990's, the overall aim of launching the Green Revolution was the fight against Communism.

[17] Source: Chicago (USA) cereals stock exchange market.

[18] Source: country consumer prices indices reports of Ethiopia Central Statistic Agency.

Policy focus

Funds for investment in irrigation development are scarce. Investment decisions should be based on economic viability, profitability for farmers and assured market opportunities. This calls for careful economic analysis of projects based on realistic assumptions on yields and rate of adoption of technology packages. Governments need establishing procedures for adequate selection and monitoring of engineering firms and consultants in charge of feasibility studies and design. Economic analyses of the proposed irrigation and drainage projects for this study are presented in the engineering component report.

In the Eastern Nile countries irrigation development planning is based on land and water availability and on projections of the national demand and supply concept of economic sectors such as agriculture, demand of agro-industries and domestic consumption. This is a sound starting point but planning of investment in irrigation development should also be tailored to economic plans in agriculture and other sectors, and to existing institutions and infrastructures.

Ethiopia

In Ethiopia agriculture contributes to 44% of the GDP (source MoFED 2006) and is the mainstay of Ethiopian economy employing approx 80% of the country workforce. However Ethiopia has an average annual food deficit of 10 million tons of cereals. Rain-fed agriculture is largely dominant and covers approx 12 million ha and is characterized by small scale subsistence farming. By comparison, total irrigation development is estimated at 340,000 Ha. For the agricultural sector, the main objective of the PASDEP is to shift from subsistence agriculture to a market oriented agriculture production through capacity building, introduction of improved technology package and establishment of appropriate marketing systems; in other words Ethiopia wants to achieve its Green Revolution. In this context, irrigation development can be a springboard for economic development through acceleration of agricultural development, development of agro-industry, training of farmers and extension staff, development of technology packages, watershed management and promotion of on-farm rain water management. But the contribution of irrigation alone will not ensure food security.

For instance assuming that the target of adding 487,000 ha of land under irrigation as per the PASDEP is reached and a production equivalent of 5 tons/ha of cereals, new irrigation development will increase production by approx 2.5 million tons, 25% of the chronic food deficit. The best option is probably to adopt an integrated rural development approach. Such an approach combines new irrigation development with other investments in rural infrastructures and watershed management and in programs for increasing access to inputs, information and markets; and strengthening local institutions. Here, the main challenges are the design, management and evaluation of complex integrated rural development projects and of course meeting the financial requirements for these investment and programs.

In the Nile basin, the Ethiopian government has selected two "growth corridors" for priority intervention, i.e. Tana and Beles sub-basins and Anger and Didessa rivers sub-basins. This is an opportunity for linking irrigation development with wider rural development projects.

Sudan

Sudan has a legacy of ageing irrigation infrastructures and technical and managerial difficulties. Productivity of existing irrigation schemes remains low and has not allowed capital accumulation by irrigating farmers' households. Based on this and the increasingly constrained water resources, the focus should thus be more on investment for improving the productivity and water use efficiency in existing schemes rather than new irrigation development. In other short, the policy focus should be on using water better rather than using more water.

Yields of main crops, i.e. cotton, wheat and sorghum does not exceed 40% of research yields in Sudan large irrigation schemes are about 30% and cropping intensity does not exceed 50% although it can potentially reach 100%. Hence, there are evidences for substantial increase of irrigated agriculture production before any irrigation expansion. A reasonable target could be increasing yields up to 60 – 70% of research yields and cropping intensity to 75% or above. Related challenges lie in improved irrigation and drainage technology and managerial changes. A very special attention should be paid to improve drainage condition that would increase yields of crops and offer opportunities for reuse of water.

Egypt

Egypt is a water scarce country, thus investment in the irrigation sector should focus on responses to water scarcity. Possible responses are varied but can be classified in three categories: (1) Supply augmentation, (2) conservation of water and (3) reallocation of water. Table 24 synthesizes possible responses to water scarcity in Egypt. It distinguishes between levels of implementation. Responses already implemented in Egypt are underlined.

Table 24: Responses to water scarcity

Strategy	Implementation by	Possible actions
	Regional cooperation	Conservancy projects in Sudan Change management of Aswan dam and water storage in Ethiopia
Supply augmentation	Ministry of Water Resources and irrigation	Improve Nile dams management Use of renewable groundwater Reuse of drainage water
	Farmers level	Pumping of drainage water, groundwater or "dead storage" of field canals (marwas) (informal solutions)
Conservation	Government	Line canals Improve water control Awareness campaigns (Activities of the Irrigation Improvement Programme)
	Farmers level	Adopt pressurized irrigation (only in reclaimed land) Change cropping techniques*
Allocation	Ministry of Water Resources and irrigation	Sector reallocation policy**
	Farmers level	Adopt short duration high yielding varieties Shift to higher value crops Arrangements for greater equity (informal)

* The Egyptian government estimates that additional yield gains could be achieved with improved seed quality, more mechanization and better soil management. ** The current agricultural development strategy plans a gradual increase of the area under wheat and to the detriment of berseem and a decrease in the area under rice.

More generally sector allocation policies imply that any increased demand in a specific sector should be met by an equivalent reduction in other sectors.

Additional water supply to Egypt or in other words re-opening the Nile basin in Egypt implies enhanced regional cooperation. New investments should seek to reallocating water to higher valued uses (domestic, industry, navigation). Egypt has by far the most diversified economy among Eastern Nile countries and agriculture represents only 15% of GDP compared to 44% in Ethiopia and 39% in Sudan. However agriculture still employs approx 35% of the economically active population and the major challenge lies in providing off-farm employment opportunities for the large number of small scale farmers and their descendants. On the other hand Egypt is one of the world champions of water use efficiency and other countries could benefit of its expertise through regional cooperation.

Capital investment

Ethiopia

Irrigation is very little developed in Ethiopia. Irrigation capital investment will go to the construction of reservoirs and open canals irrigation schemes. The related challenges are (1) the risk that irrigated area grows quicker that the institutions needed for securing irrigation productivity and sustainability or in other words directing most of investments to the "hardware" to the detriment of the "software" and (2) project design, i.e. risk of adopting a top-down approach for the sake of rapid results on the ground and over-optimistic assumptions about costs and benefits to obtain attractive costs/benefits ratios. It is widely recognized that irrigation performs better and is more effective in addressing poverty if complementary investments such as roads, storage facilities, electrification, agro-industries and so on are made or already exist. This is an incentive for combining irrigation investments in a more general approach of investments for integrated rural development.

Egypt

Most of irrigation investments should be directed toward a greater water control. The Irrigation Improvement Program is addressing this issue at field canals and farm level. Software technologies as automation based on communication systems and computers are becoming cheaper, more reliable and more available. Adopting these technologies would improve water control in Egypt through automation for monitoring and control of canals systems; and measurements of canal discharges and even on-farm water deliveries. High productivity of irrigated farming has eventually allowed maintaining the large farming population (average farm size of 1.5 feddan) just above poverty line. As population grows, investments in rural economy other than irrigation (industries, services) could ease population pressure on agricultural lands through provision of off-farm job opportunities.

Sudan

The country's liberalization policy wants to transfer the management of the large public irrigation schemes to farmers' organizations. This calls for prior investments in the rehabilitation of the ageing and degraded irrigation systems. Sudan large irrigation schemes would not have been built the way they were if they were intended to be managed by farmer's organizations. Thus the issue is more the modernization of irrigation schemes than repair of existing infrastructures; see chapter 3.7 on irrigation technology. Other investments in rural infrastructures are needed, for example upgrading roads within the schemes, rehabilitation and modernization of agro-industries.

Cost recovery and water pricing

The least one can say is that cost recovery or water pricing strategies are not popular amongst farmers. However the issue has come back to the top of the agenda of governments of the Eastern Nile countries in the 1990's because of increasing budget constraints in line with structural adjustment and other financial austerity measures prescribed by the IMF[19] and the World Bank. Funding for housing, infrastructures, education and social services in both urban centres and rural areas compete with requirements for irrigation. The first rationale for cost recovery or water charging strategies is thus reducing national budget expenditures. The second rationale is ensuring the sustainability of irrigation schemes and avoiding the frustrating cycle of project degradation / rehabilitation in which development banks and governments often get caught up as in Sudan.

Recovery of capital investments

There is some doubt as to who should pay for irrigation infrastructure development, farmers or the tax payers through public subsidizes. It is clear that a significant proportion of irrigation benefits does not go to farmers but to the non-farm sector which benefits from expanded opportunities flowing from irrigation development, the so-called "multiplier effect". The general situation, including in developed countries, is that very little, if any of the costs of public investments in irrigation infrastructure is recovered from users. Activities of the Irrigation Improvement Programme in Egypt (single pump lifting and lining field delivery canals) make an exception as it can be seen as on-farm investments which most of the benefits go to farmers. In line with the former, on-farm capital investment for large commercial irrigation should be fully paid by the investors.

Operation & maintenance (O&M) costs recovery.

There is wider general agreement on farmer users paying for irrigation services and cover operation and maintenance (O&M). This is on the agenda of Ethiopia and Sudan irrigation policies but not in Egypt. Regarding the first rationale, cutting government budget expenditures, it is often unclear (1) whether such costs are really as considerable as it is claimed, in Ethiopia and Sudan, they correspond to approx 3% of the investments costs of new irrigation projects[20]; (2) why users should pay for a service which is unsatisfactory and unreliable as it happens more often than not in Sudan public irrigation schemes; and (3) how the particular subsidy of free or low O&M fee features in the wider arithmetic of taxes and subsidies that occur all along the production chain, from inputs provision to final consumption. In other words, if the overall taxation results in a net extraction of surplus, the rationale for raising water fees might appear less convincing.

A possible option in Ethiopia and Sudan for new irrigation development or for rehabilitation projects would be a progressive increase of the O&M fee during the time necessary for establishing a satisfactory and reliable water service and farmers' adoption of improved technology packages. Successive increases of the O&M fee should be discussed and agreed on with representatives of farmers and backed with guarantees of improved water service. Under such conditions a progressive rise in water charges, matched by increased profitability of irrigated agriculture, is a sensible option for reducing public funding in irrigation.

Second, O&M cost recovery is also deemed critical to ensure the sustainability of irrigation schemes. Past experience in Sudan and in Asian countries call for the establishment of mechanisms whereby the money raised is directly reallocated to the covering of O&M costs, ideally under the control of the users themselves. If such mechanisms are not in place, no clear link is established between payments and O&M performance and defaulting is generally high.

[19] IMF: International Monetary Fund.

[20] Source: Abbay Master Plan pre-feasibility studies of irrigation projects, Upper Atbara feasibility study.

A possible option is greater farmers' participation in O&M of public irrigation schemes, which, as noted in the following chapter, has had mixed success in developing countries. Another option is "People Public Private Partnerships" to facilitate private sector provision of services not only for irrigation O&M but also for other agricultural services. This corresponds to a redistribution of power and responsibility away from the administration. Implementing this option supposes a strong policy commitment at the highest level to overcome the reluctance of irrigation bureaucracies for abandoning its power position and reducing their staff.

Water pricing

The investments and transaction costs that would be associated with volumetric water charging in the Eastern Nile public irrigation schemes are not justified. In other words volumetric water pricing is not feasible in irrigation schemes with a large number of small scale farmers. However charging water in bulk or according to volume used is a possible option for large scale commercial farming in the same way as in the industrial sector.

Credit

For various reasons, the vast majority of farmers in the Eastern Nile Basin live close to the poverty line even those with access to irrigation. Generally commercial banks do not make loans to poor people with insufficient assets as a guarantee against defaulting. Formal rural credit and saving institutions are crucial to fuel irrigated agriculture production through facilitating farmers shift from subsistence (or survival) logic to market-oriented (or entrepreneur) logic. This need is particularly pressing in Ethiopia and Sudan where rural credit is almost inexistent. Option for subsidizing rural credit should not be written off simply because of financial orthodoxy considerations.

Capacity building

Irrigation scheme designs sometimes do not match the management capacities of agency staff, water user associations, or farmers. Even simply structured large-scale irrigation systems require well trained professional managers and operators to achieve acceptable levels of performance in water delivery service. Lack of managerial capacity is perhaps one cause of the mixed performance of Sudan large public irrigation schemes. Formation and capacity building of Water Users Associations (WUAs) in the three Eastern Nile countries require the design of specific capacity building programmes to provide the WUAs with adequate management tools and methods; see § 3.6.1. In Ethiopia, lack of skilled irrigation professionals at local (woreda) and even at regional state level is a serious concern.

To deal with the likely reduction of public extension service because of financial constraints, the links among smallholder farmers, the private sector operators, and government staff for the provision of technical support services in various fields (i.e. crops, water and financial management at scheme and farm levels, market information and so on) needs to be developed. This relates to the World Bank call for PPPPs: People Public Private Partnerships. Innovative approaches, such as the farmer field school, participatory diagnosis, involvement of NGOs will also be needed to compensate for the reduction of public extension services. Themes of extension message should also evolve from the sole dissemination of technology packages toward provision of management tools, market information and contract negotiation.

More generally, the successes of the Green Revolution were also based on the implementation of mass education-related strategies. To get out of subsistence farming, farmers must be able to read information leaflets, make purchase orders or invoices, hold a basic bookkeeping system, and clearly explain the causes and consequences of a specific problem. Failures of the Green Revolution in most of Sub-Saharan Africa were largely due to a lack of basic education. Needs for educational programs will increase with the development of biotechnologies.

Land tenure

The tenancy system in Sudan was designed in the 1920's for the Gezira irrigation scheme and has served as a model for the other large public schemes. It has become increasingly unsatisfactory as a result of social and economic changes. In Ethiopia, the legislation on land rights should be assessed with a view of offering better guarantees to farmers about land security. Land reforms are a complex and highly political issue that cannot be addressed within the framework of the present study. Issues of common interests that can be addressed through enhanced regional cooperation are cost recovery mechanisms, irrigation and agriculture technology and capacity building.

Table 25: Summary of priorities for irrigation development in the Eastern Nile countries

	Ethiopia	**Sudan**	**Egypt**
Policy focus.	Integrated rural development	Improving productivity and water use efficiency	Reallocation of water to higher valued uses
Capital investment, irrigation.	Open canals irrigation development	Modernization of irrigation & drainage infrastructure and technology.	Increasing water control
Capital investment, others.	Rural infrastructures, market, social services	Upgrading rural infrastructures	Creation of off-farm employment
Cost recovery	Progressive increase of O&M fee		Full cost recovery of upgrading on-farm irrigation infrastructure and technology.
Irrigation management	Improved irrigation systems control and operations.		
Capacity building	Training of irrigation staff and farmers.	Formation and strengthening of WUAS, market information systems	
Credit	Rural credit, micro credit, grants.	Rural credit	Rural credit, Commercial financing.
Technology irrigation*	Improved hardware for flow control in irrigation canals		Improved hardware fro flow control in irrigation canals. Pressurized irrigation systems Automation
Technology, agriculture*	Rational utilization of Green Revolution technology packages Precision agriculture.	Rational utilization of Green Revolution technology packages	Rational utilization of Green Revolution technology packages Precision agriculture Biotechnologies

*See § 3.7.

3.6 CHALLENGES AND OPPORTUNITIES RELATED TO INSTITUTIONS

Public administrations of Egypt, Ethiopia and Sudan have long been and still are predominant actors of the irrigation sector. For the government of both countries, one negative outcome of many years of state monopoly regarding investment and management of the irrigation sector is high public expenditures. Since the 1990's, the governments of Egypt and Sudan actively advocate and implement reforms emphasizing a reduced role for the public administration and a larger one for farmers and the private sector. Sudan's strategy also emphasizes cost recovery of O&M in all irrigation schemes. Ethiopia Water Sector policy for the irrigation sub-sector advocates the establishment of "*self-financing autonomous public institutions to undertake O&M activities of large scale irrigation schemes*" and more generally, the development of "*appropriate institutional structures for the implementation and management of irrigated agriculture*". Here again the interest of governments of the three Eastern Nile countries rests in large part on their desire to reduce expenditures in the irrigation sector.

3.6.1 The changing role of governments

Governments will remain in charge of planning and financing of major irrigation infrastructures as they have done since many years. The Ministries in charge of irrigation will continue their activities related to design of irrigation systems, contracting and supervising civil works. Governments will continue to play the role of water wholesaler by operating large and strategic facilities such as dams and major irrigation infrastructures such as main canals and pumping stations. However, ministries in charge of irrigation will have to adapt their activities to the increasing shift of management responsibilities to users and the greater involvement of the private sector. New responsibilities include regulation, and water resources management. As this is a common issue in the three Eastern Nile countries it offers a potential for regional cooperation, i.e. exchange of experience and information, harmonization of policies and legislations.

Regulation

Because water is a public good, the state has a duty to sustain its quality. Users often enjoy the benefits of water use while passing on environmental and social costs to others, leading to problems of equity, environment degradation, poor working conditions of farm workers and in some cases contamination of consumer products by pesticides or germs. The state should play a greater role in regulating these externalities. Moreover, in the logic of integrated water resource management, water will increasingly become an economic good quantified and governed by agreements among users and between public authorities and users. Governments will have to play an important role in sanctioning and regulating these agreements. To carry out these responsibilities, the best option might be to separate regulatory public agencies from public water management and supply agencies to avoid conflicts of interest.

Assessing and collecting water fees have been a key role for public agencies (i.e. in Sudan). With the devolution of irrigation system management, financing structures will need to change as well to allow sufficient funds to sustain operations to those who actually run them (see "Cost recovery of O&M in 3.5.2.); related risk is the design of over-complicated costs recovery mechanisms.

The issues of large commercial private estates are directly related to questions of equity and environmental sustainability, including soil and water pollution, land and water allocation and living conditions of farm workers (wages, housing, health and so on). These issues require public intervention, and regulatory frameworks are needed for equitable and secured use of land and water resources for large and small scale farmers. Well targeted public interventions are also needed to stimulate the private sector through incentive policies and targeted investment in bulk infrastructure and to enable private sector provision of on-farm irrigation and agricultural technology.

Resources management

With increasing pressure on water resource at the Eastern Nile basin level and increasing water scarcity in Egypt and to a lesser extent in Sudan, the focus must be the definition and the security of water entitlements or water rights at different levels and different categories of users. A prerequisite is quantification of water supplies, water delivery and uses. Without quantification, it is not possible to establish workable water rights. River basin agencies are often proposed as a key solution, but well orchestrated institutional development between existing public agencies can be as effective.

3.6.2 Water Users Associations (WUAs)

WUAs are seen by many governments in the developing world and international development agencies as an essential element for reducing public expenditures and for improving irrigation performance. Since the 1990's, the transfer of management and financial responsibility to WUAs, at least at the lower level of large schemes, has gained popularity. The terms for this are Participatory Irrigation Management (PIM) and Irrigation Management Transfer (IMT).

According to the definition given the International Committee of Irrigation and Drainage (ICID), PIM refers to *"to the level, mode and intensity of user group participation that would increase farmer responsibility in the management process"*. IMT is a more specialized term that refers to the process of shifting basic irrigation management functions from a public agency or government to a local or private sector entity.
PIM and IMT are underlain by three main processes. The first one is the enduring populist call for community-based management and turnover of management to users, based on the claim that local knowledge must be tapped to ensure sustainable use of irrigation schemes and natural resources. The second one, borrowed from an anti-state stance, favours privatization and sees users as independent entrepreneurs who must have control over their input and pay for resources at their real value, as reflected by their market prices. This ideological stance is often put forward to obscure that PIM and IMT are driven by state financial difficulties and the inability to cope with growing O&M costs. The third process is a more general trend towards democratization, with a growing recognition of the civil society. Such a political process is, of course, not deprived of ambiguity and combines the emergence of genuine local democracy with the capture of new positions of power by particular interests.

Institutional IMT or PIM reforms have recently started in Egypt and Sudan and so far there is very little documented information regarding impact. In Sudan reforms are being implemented in the Gezira irrigation scheme since 2005. In Egypt surveys in pilot sites of the Irrigation Improvement Project showed that increases in net farm profits were between 30% and 50%. Elsewhere, recent experiences in IMT or PIM seem to suggest that there has been considerably more success in transferring management responsibilities in more advanced countries such as Turkey and Mexico than in the developing countries of Asia and Africa. Where implementation has been successful, government expenditure and the number of agency staff has declined, maintenance has in some cases improved, but there is little evidence yet that PIM or IMT have led to an increase in the productivity of irrigated agriculture. In Africa, the only successful case of partial IMT is Office du Niger (OdN) in Mali. The Office has achieved a turnaround from a top-down centralized approach to one that is more service oriented and which, by combining selective investment in hardware with institutional change, has produced impressive results, i.e. yields of paddy rice increased dramatically from 1.6 t/ha to 6.0 t/ha (Box 3). It is worth pointing out that it took more than 20 years to implement institutional reforms in OdN and that the work is still unfinished.

Box 3: Successful public large-scale irrigation in Mali, the Office du Niger

The Office du Niger (ON), located in the heart of Mali, is one of oldest and largest smallholder irrigation schemes in Sub-Saharan Africa. When development of the scheme began in 1932 it had been intended to develop about 1 million ha over a period of 50 years. By 1982, however, only 60,000 ha had been developed, of which a large part had been abandoned owing to poor maintenance and operation. Cotton production had ceased, and average paddy yields had slumped to 1.6 t/ha. Attempts to rehabilitate the scheme proved successful when physical investments to improve water security were matched with institutional reforms. An impressive turnaround has been achieved: in addition to the 50,000 ha that was still in use at the time, about 10,000 ha of previously abandoned land was reclaimed and put to productive use, and average paddy yields have increased to 6 t/ha. O&M cost recovery has reached 97 %.

These results are attributable to a combination of factors, including:
- Irrigation system improvement and modernization
- Improved water control and management
- Adoption of improved technologies - high-yielding varieties, fertilizers, improved husbandry practices
- Liberalization of paddy marketing and processing facilitated
- Improved land tenure security
- Institutional restructuring, including: privatization of most commercial functions, contracting out of maintenance works to the private sector, downsizing of the management agency and concentration on its core activities of bulk water supply, land administration and agricultural extension more participatory approaches that engage farmers in management decisions – e.g. on O&M fees

Underpinning this success was the long term commitment (over more than 20 years) of government and managers, and the sustained support of external partners. The work at ON is, however, not yet complete: there is more to be done on strengthening farmers' organizations, improving land tenure security and making the irrigation agency more accountable to farmers.

Source: Couture and al (2002); translated from French

The reason why PIM and IMT approaches have met limited success is that preconditions for the establishment of successful farmers-managed WUAs including government commitment exist in some areas but not in others. The main conditions for success and reasons for failure of institutional reforms are presented in box 4.

Many IMT reforms have been based on two simplistic if not false assumptions. The first one is that the irrigation bureaucracy would easily accept IMT and abandon its power. The second assumption is that greater user participation will automatically result in improved irrigation performance and that users will be increasingly interested in the management of their irrigation service as the state retreats from providing and financing its provision. However, much has to be learned about how to do this effectively in practice without resorting to simplistic ideological stances that have been prevalent over the last two decades.

Box 4: Main conditions for success and reasons for failure of IMT.

Conditions for success	Reasons for failure
Strong political backing	Lack of political support.
Legal framework for WUAs	Unclear sharing of responsibilities between WUAs and the administration
A clear role for WUAs and other stakeholders	Resistance of public agencies and water users
Capacity building and empowerment of institutions at all levels (including water user associations and local governments)	Lack of funds and technical capacities
Real autonomy of the water user associations	Resistance of public agencies and water users
Functioning irrigation infrastructure.	Transfer of dilapidated or badly designed infrastructure that needs major improvement.

To be viable, private water services must be based on reliable and measurable provision of water or "water rights", this relates to management practices and irrigation infrastructures. Also needed are adequate legal frameworks for WUAS defining their roles and responsibilities as well as their relationships with the administration. Another reason for failure of IMT or PIM often lies in the emphasis on water by irrigation departments. Low performance of irrigated agriculture may be the result of non-water-related constraints (markets, inputs supply and so on), in which case irrigation management reforms will be of little attractiveness for farmers.

Institutional reforms in irrigation management cannot succeed in a vacuum and depend heavily on broader reforms in governance in particular the relationship between farmers and administration; and more generally on the much wider issue of democracy.

Opportunities for regional cooperation work.

Capacity building and formation of WUAs is a concern in the three Eastern Nile countries. Exchange of experiences in PIM and IMT across the Eastern Nile countries can help better defining the strategy and the process for establishment of strong and efficient WUAs.

The strategy is very likely to address a population, which is not homogeneous: farmers would have diverging or even antagonistic interests in irrigated agriculture. The formation of WUAs also takes place in an uncertain environment (markets, land redistribution, progress made in the completion of the project, etc).

Complexity and uncertainty call for a strategy that rather than sticking to a pre-established trajectory, should adopt a step by step approach striving to foresee, adapt to, and benefit from any new issue, emerging situation or unexpected event with the objectives of defining widely accepted rules and management principles and setting the operational framework of the WUA.

Objectives of capacity building are providing knowledge and information enabling monitoring and assessment of the activities performed and orienting management decisions. This knowledge and information should materialize under the form of a series of ***management tools*** such as, by-laws, performance indicators, worksheets for maintenance, irrigation schedule, bookkeeping system, communication mechanisms and so on.

The strategy for formation and capacity building of WUAs should address the issues of assets and legal status. To perform their activities, WUAs need assets: office space and equipment, means of transport and communication, running capital, and so on. A legal status enables WUAs to act as legal entities to pass on contracts with external public or private organizations, employ personals, open a bank account and access to credit, defend their interests, be represented in forums dealing with irrigation issues, etc.

T***he process*** should be participatory by involving future beneficiaries and other stakeholders that are concerned by O&M at various levels including the agency or the consultant in charge of the design of the irrigation infrastructure. Starting the process with a stakeholder analysis will allow to identifying these stakeholders and assessing the inputs they can provide at various stages of the process.

The process should start at the earliest possible phase of an irrigation project so that all stakeholders are also involved in project planning and the design of irrigation schemes and continue over the first years of operation. As a consequence it should be coordinated by a local or regional institution that would ensure its continuity over time. Ideally the same institution should then continue providing technical and institutional support within the framework of regular extension work.

Owing to the complexity of WUAs and uncertainty of their socio-economic environment, the process should not seek the adoption of ready made management tools or recipes, but rather favours information sharing among farmers and between farmers and other stakeholders, mutual learning and collective awareness. It should aim helping all stakeholders to share a common representation of the WUA, making well informed decisions and anticipating the possible evolution in the life of the WUA.

During the operation phase, the process should involve a progressive reduction of guidance and support by the staff of the coordinating local/regional agency and a progressive handing over of tasks and responsibilities to the WUA. In doing this, a specific attention should be paid to financial management. Mismanagement of the WUA funds, for instance the O&M fee, leads to distrust and conflicts among farmers and eventually failure of the WUA.

3.6.3 Private sector

Commercial farms: Privately owned commercial farmers are little developed in the Eastern Nile countries. In Egypt they are confined to reclaimed desert land. In Sudan, commercial farms involve a number of smaller schemes along the Blue, White and main Nile; but it seems there are important new private investments in the proximity of Khartoum. In Ethiopia, commercial farming is limited to the production of horticulture products (mainly flowers) in green houses-equipped estates located in the Rift Valley and in the vicinity of Addis Ababa; large investment projects for private sugar cane plantation some are in the pipeline, for instance in the Beles and Didessa sub-basins. Compared to large scale irrigation or community managed small scale irrigation; commercial farms have in general a greater impact on agricultural production and a lower impact on poverty reduction as most of the benefits are not reinvested in the local economy.

P*eople Public Private Partnerships:* The range of institutional options for PPPPs is broad, from private sector 'third party' management of public schemes as now proposed in Ethiopia, to simple facilitation by government of private sector investment, as in Egypt and Sudan. One attractive model of PPPP is the Green Scheme in Namibia, where since 1994 the government has developed basic water delivery infrastructure and allocated 50% of the irrigated area to larger scale farmers who then provide water and other services (technical advices, marketing) to smallholder farmers. This business line is likely to be the mechanism for most World Bank financing of large scale irrigation in Africa. (See note on World Bank strategy for reengaging in agricultural water management in appendix 2).

3.7 CHALLENGES AND OPPORTUNITIES RELATED TO TECHNOLOGY

Water management and agricultural technologies are key factors of agricultural growth in the Eastern Nile countries. Irrigation and agriculture technology can be one theme of regional cooperation through joint research and development projects, exchange of information, capacity building of irrigation staff and farmers.

3.7.1 Irrigation technology

Many of the disappointing results of turnover, participatory management or irrigation agency reforms eventually stem from difficulties with both infrastructure and management required to establish steady and predictable flows in distribution systems and these difficulties are already happening in Egypt and Sudan. At their design stage large scale irrigation systems in Egypt and Sudan were not intended to be managed by farmer's organizations. Large scale irrigation schemes in Egypt and Sudan are equipped with water control devices such as manually operated gates and moveable weirs that are difficult to operate properly even by well trained government agencies staff. In Ethiopia recent feasibility study of new irrigation schemes (i.e. Koga, Arjo Didessa, Humera) also recommend the same type of old technology which was developed in the first half of the 20th century. Irrigation technology for new irrigation development or modernization of existing schemes should respond to the need to increase productivity by lowering risk and uncertainty, but also more generally, to the necessity to increase and facilitate control over flows by users. This is a prerequisite to improved water distribution and to the definition of service agreements or water rights. These technologies already exist, particularly the hardware for greater flow control and measurement in irrigation canals. Considerable opportunities can be expected from software technology as electronics, communication systems, computers, and instrumentation become cheaper and more available. Automation for monitoring and control (including supervisory control and data acquisition in canal systems) and measurement (canal discharges, and even on-farm and water deliveries) is a potential for greater water control in large scale irrigation schemes.

3.7.2 Agricultural technology

Utilization of the Green Revolution technology packages causes serious environmental concerns, namely surface and groundwater pollution by nitrogen, phosphate and pesticides. In Egypt, one of the main challenges for the sustainability of water resources is the control of water pollution. The Ministry of Agriculture is advocating organic farming and limiting the use of chemical fertilizers and pesticides to reduce water pollution. In addition, present policy is to minimize the use of herbicides and to depend mainly on the mechanized control of submerged weeds and water hyacinths. Ethiopia and Sudan irrigation sub-sector policy includes the following policy track: "minimize and mitigate as much as possible the negative environmental impacts associated with irrigation development".

Rationalizing the use of fertilizers and pesticides: It is now recognized that intensive agricultural systems may cause water and soil pollutions. Furthermore a significant part of inputs (fertilizers and pesticides) is lost because application rates are either excessively high or poorly spatially distributed or not timely. An effort of rationalization is thus necessary for greater control of fertilizers application rates to avoid losses or limiting use of pesticides according to pre-defined thresholds above which pest infestation causes significant economic losses. Adopting this option would limit environmental pollutions and improve the ratio yields / production costs. The economic objective is maximizing monetary income per hectare and not the production per hectare.

Precision agriculture: The concept of precision agriculture is based on application of inputs including water "just in place" and "just in time". In the real world precision agriculture is already put in practice by many smallholder farmers growing horticultural crops. It is facilitated by pressurized irrigation technology and fertigation. Precision agriculture implies that farmers have a permanent access to their fields to apply water, fertilizers and pesticides and mechanized weeding when and where it is necessary. It can thus be envisaged on small farms and where labour availability is not a constraint. This may be the case in Egypt and in irrigation schemes with smallholder farmers in Ethiopia. On the other hand, precision agriculture is very difficult for mechanized farming systems because access to fields by farm machinery is possible only at plantation time and during the very early stage of the crops growing period provided that soil moisture conditions are favourable.

Greener Revolution: The term of Greener Revolution comes from a working group of researchers initiated in 1994 by the Consultative Group for International Agricultural Research (CGIAR). The Greener Revolution concept is an attempt to find the right positioning between organic farming and inputs intensive farming. The objective is high productivity by using and preserving the functionalities of the ecosystems. Like organic farming, it favours the use of the biological processes within the ecosystems for production purpose, but unlike it, it does not prohibit the use of chemical fertilizers and pesticides. Most of the Greener Revolution techniques are still at the experimental or research stage. Some of them have been tested with encouraging results such as agro forestry and zero tillage practice or conservation agriculture.

Biotechnologies consist in modifying the genetic characteristics of crops or livestock to generate gains of productivity in the use of agricultural inputs: labour, land, water and so on.

Research in the biotechnologies sector focus on:

- A greater resilience of crops to pest and diseases, main concerned crops are rice, maize, cotton, soya and potatoes;
- Crops tolerance to unfavourable climate and soil conditions for instance: development of drought tolerant varieties of maize and sorghum, development of soil salinity tolerant crops, development of wind tolerant banana varieties;
- Transfer of the property to use atmospheric nitrogen as do leguminous crops with a view of reducing production costs and controlling environment pollutions.
- Increase of potential yield: At present, yields of new rice varieties are in the vicinity of 20 tons /ha in research centres in Asia.

New crop varieties are developed through conventional breeding methods or increasingly through crop genetic modification. Genetically modified maize, colza and cotton are already used by farmers in the USA, Canada, Argentina, Brazil, China, India, South Africa and surprisingly Burkina Faso (Cotton). The European Union has authorized the cultivation of genetically modified crops for experimentation purposes but not for production because of uncertainties about their impacts on environment and health. On-farm utilization of biotechnologies demands very high technical capacities.

3.8 CONCLUSION

All Eastern countries have ambitious irrigation expansion plans. Egypt and to a lesser extend, Sudan are faced with physical water scarcity. One could also argue that Egypt is also facing political water scarcity, meaning that they might be too much water allocated to irrigation relative to other uses. In Sudan water there are strong evidences that the issue of water scarcity can be addressed by improving the productivity and water use efficiency in irrigation schemes. Ethiopia faces economic water scarcity, meaning that so far the country has lacked of capital for investments in water development. However Ethiopia is now entering an era of construction of reservoirs and irrigation canals and will use more and more of its currently almost untapped water resources; the main challenge for the country is setting up the appropriate institutions to ensure high productivity and long term sustainability of irrigation development.

The Easter Nile basin is a closing basin where there is excess water during the high flow period only. Most of this excess water is lost by evaporation in reservoirs in Sudan, the lake Nasser and in the river system during floods. The best opportunities for storing water and reallocating it during the low flow period lie in the construction of reservoirs in the upstream part of the basin in Ethiopia. This calls for new institutional arrangements regarding the definition and security of water entitlements, or "rights". Water allocation among users at country, sector, irrigation systems and farm level must be negotiated, made transparent and enforced technically and legally. Quantification of water supplies, delivery and uses is a prerequisite; without quantification it is not possible to define workable water rights. A pilot project "Transboundary irrigation development in IDZ 3 & 4 is introduced in part V of this report.

Productivity of irrigated agriculture eventually stems from water management and technologies. All Eastern Nile countries want to address the issue of irrigation management transfer to farmers-based organizations or private sectors entities. Strategies and processes for achieving irrigation management transfer are issues of common interests and can be addressed through cooperative activities such as capacity building, and exchange of information and experience. Regarding technologies, Egypt is the most advanced country and cooperative activities should focus in a first time on the transfer and adaptation of Egypt's expertise to the other countries. Software technologies for monitoring, control and measurement of water either in river systems or in irrigation schemes already exist and are becoming cheaper. This is an incentive for cooperative activities such as capacity building of irrigation staff, joint research and development projects and joint investment in software technologies. A pilot project "Modernization of irrigation and drainage technology in the Eastern Nile basin" is introduced in part V of this report.

Governments have long been and still are predominant if not sole actors of irrigation development. In the present period of market-based economy and cost recovery, new actors are emerging such as farmers-based organizations and the private sector. This implies well targeted accompanying measures and new roles for the state regarding regulation of water uses and allocation of water among users and sector uses.

About regulation, water pollution by fertilizers and pesticides is a major concern in Egypt. With irrigation development and adoption of intensive agricultural practices, this concern is likely to extend to Ethiopia and Sudan. Because water is a public good it is the responsibility of the state to sustain its quality and because Eastern Nile waters are transboundary, this issue is of regional interest. It can be envisaged to establish and enforce common regional environmental regulations.

At the Eastern Nile basin level, the main challenge of irrigation development and management, and more generally water resources management in the coming years is to make compatible two opposite and, at first sight, contradictory trends. The first trend is decentralization or in other words shifting irrigation management to users and tailoring irrigation investments and technology to local physical and socio-economic conditions. This trend is underlain by desire of government to curb expenditures in O&M of irrigation schemes and by concerns related to sustainability and management efficiency. This cannot be addressed by top-down intervention driven by particular ideological agendas or blueprints focused on a particular arrangement. Following Ostrom (1992), it must be recognized that: "… any single, comprehensive set of formal laws (and ready made technology packages) intended to govern large expanse of territory and diverse ecological niches is bound to fail in many of the habitats where it is supposed to be applied. Such a match between institutions, (technology) and physical, biological, and cultural environments can only be achieved when the people concerned are able to be fully involved in the process of institution building".

The second trend is centralization whereby the logic of integrated management at basin level calls for the development of regulatory institutions or mechanisms operating at basin level. These organizations need the involvement of the state in order to define or regulate water allocation and to offer mechanisms for conflict resolution. A major risk is that these institutions or mechanisms end up being dominated by bureaucratic thinking and top-down initiatives.

The allocation and access to water among users and sector uses at the basin, irrigation systems and farms level must be defined through a formalized process whereby the nature of water as both a public and an economic good is made explicit and water sharing is negotiated between and within countries. The best option might be to build consensual water allocation patterns by negotiation under the umbrella of a future Eastern Nile basin organization or a well orchestrated institutional development between national public agencies in charge of water resources and irrigation giving a say to all stakeholders. This is in line with the "Shared Vision" of the Nile Basin Initiative. It will take time to establish enforceable water rights and a complementary set of institutions at basin, country and irrigation system levels. The task is monumental as are the challenges ahead for the Nile Basin Initiative and supporting Subsidiary Action Programmes.

4. Part III: Institutional Analysis

SECTION 1: INTRODUCTION TO THE INSTITUTIONAL ANALYSIS

4.1 METHODOLOGY

The first step was to craft an analytical framework on which to apply the multi-criteria analysis: Table 26 refers. It should be self-evident that some cells are irrelevant and equally, that some cells would have more processes than others.

The next step was to articulate objectives for each *Level of Cooperation* (vertical axis) and then to identify the institutional constructs suggested by them. These were then compared with existing arrangements in each country and in the region - where possible or relevant. This allowed the current arrangements to be assessed in terms of their strengths and weaknesses with respect to the Level Objectives and the needs for any adaptation or new arrangements identified.

Table 26: Analytical Framework

LEVEL OF COOPERATION	OBJECTIVE	PROCESSES FOR COOPERATION						
		no change	adaptation of existing arrangements			new arrangements		
		(national or regional)	national	regional	both	national	regional	both
Level 1	Objective of Level	process 1	process 1	process 1	process 1	process 1	process 1	process 1
		process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc
Level 2	Objective of Level	process 1	process 1	process 1	process 1	process 1	process 1	process 1
		process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc
Level "n"	Objective of Level	process 1	process 1	process 1	process 1	process 1	process 1	process 1
		process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc	process 2 etc

Two approaches were then adopted by way of identifying possible *processes for cooperation* needed to address weaknesses in the current arrangements. *First*, examples from other river basins, in Africa and beyond, were assessed in terms of their replicability in the Eastern Nile; and *secondly*, where relevant, additional bespoke local possibilities were identified and added to the framework. In every case, efforts were made to make sure that promising arrangements extents in local policy and strategy documents were included in the framework. By this stage, the analytical framework was complete.

Next therefore, it was necessary to suggest a weighting and scoring system for the multi-criteria analysis. This too adopted a framework approach. Table 27 refers – it should be noted that it is intended that the weightings and scores suggested by the Consultant later in this document are somewhat preliminary and in the case of the scores, also subjective. As such it is intended that they are re-considered and where thought necessary, re-valued by basin stakeholders at a forthcoming regional workshop, where it is hoped that the consultant will be available to facilitate the process.

The final step was to subject each of the processes, by Level, to a multi-criteria analysis and interpret the results.

4.2 DOCUMENT STRUCTURE

The description of the Institutional Analysis comprises five sections, this being the first.

Section 2 describes the institutional challenge implicit in irrigation and drainage development in the Eastern Nile. After i) a brief introduction proposing ten *Levels of Cooperation* (the vertical axis of the analytical framework refers – Table 26) and ii) a brief history of cooperation in the Eastern Nile, current national water sector priorities are identified and analysed in terms of potential incompatibility. The associated challenges are then compared with current arrangements, which are assessed in terms of their strengths and weaknesses with respect to these challenges. This leads in turn to an assessment of the needs for new institutional arrangements at the national and regional levels.

Section 3 presents examples of how similar challenges have been faced in other river basins, in Africa and beyond. Both institutional and legislative solutions are described and are assessed in terms of both successes and failures.

Section 4 integrates the results of Part 2 (institutional needs assessment) and Part 3 (promising approaches from elsewhere) in the form of a suite of possible Processes for Cooperation with respect to each level of cooperation. The resulting analytical framework is then subjected to the multi-criteria analysis.

Section 5, comprises conclusions and recommendations which have been discussed during the Regional Stakeholders Workshop in Khartoum. The results will then be used as inputs to the regional capacity building needs assessment and specification to be carried out during Phase 3.

The Main Text is supported by the following appendices:

Appendix 3 Summary of the conclusions of the Transboundary Analysis

Appendix 4 presents a summary of existing institutional arrangements in the riparian water sectors.

Appendix 5 provides a list of important river basin organisations established between 1815 and 2002, and goes on to identify the opportunities that they represent for the Eastern Nile

Appendix 6 provides scores of the multi-criteria analysis as filled out by the consultant before the regional stakeholder workshop held in Khartoum.

Literature sources studied during the course of this analysis are included in Section 6 "Bibliography"

Table 27: Multi-Criteria Framework

CRITERIA	WEIGHTING FACTOR	INDICATORS/RANGE OF SCORES <<<Unfavourable favourable>>>					SCORE GIVEN	WEIGHTED SCORE
		characteristic to be scored						
		1	2	3	4	5		0
		characteristic to be scored						
		1	2	3	4	5		0
		characteristic to be scored						
		0	1	2	3	4		0
		characteristic to be scored						
		1	2	3	4	5		0
		characteristic to be scored						
		1	2	3	4	5		0
		characteristic to be scored						
		0	1	2	3	4		0
							TOTAL	0

SECTION 2 THE INSTITUTIONAL CHALLENGE

4.3 INTRODUCTION: LEVELS OF COOPERATION

The Consultant had earlier proposed five Levels of Regional Cooperation (BRLi 2007a). This list has now been expanded to include two more, while two of the original levels have been subdivided, giving a total of ten levels. They are listed in Table 28 which also suggests objectives for each of them. It should be understood that the numbers do not imply any ranking; they are merely relevant to the clustering of the levels into a time based typology of institutional and legislative reforms for enhanced cooperation. This explained below in section 4.7. Equally, there is no intention to suggest that some levels are more important than others – they are merely different. They could also be thought of as interdependent components of an integrated institutional strategy.

Noting that the Nile Basin Decision Support System is predicated inter-alias on four kinds of foci or benefit cluster (society, economy, natural resources and regional collaboration), Table 28 also provides an indication of the nexi between a particular level of cooperation and society, economy and natural resources (environment). The fourth benefit cluster is not addressed in this way, because the entire exercise is concerned with improving regional collaboration.

Table 28: Levels and Objectives of Cooperation

LEVEL OF COOPERATION		OBJECTIVE	AREA OF IMPACT		
			society	economy	environment
1	Information Sharing	A comprehensive, trustworthy, basin-wide and well organised suite of water resources planning and monitoring data accessible by all water planners, managers and regulators in the Eastern Nile Basin	indirect	direct and significant	indirect but significant
2	Joint activities on issues of regional interest	Win-win situations resulting from clear and mutually agreeable[21] procedures for international cooperation on a project by project basis[22]	direct and significant	direct and significant	depends on the activity; but potentially direct
3	Dialogue[23]	Transparent, participatory water resources planning and management in the Eastern Nile Basin	direct and significant	direct and significant	depends on the subject; but potentially direct
4	Creation of a regional professional body (for water managers and associated technocrats)	Technical and policy consensus and epistemic excellent between Nile Basin water managers	indirect	indirect	indirect, but potentially significant

21 i.e. consensual

22 Note that this level of cooperation will be relevant to national projects with transboundary implications as well as any basin-level investments that are implemented on an ad-hoc rather than strategic) basis.

23 This includes prior notification

LEVEL OF COOPERATION		OBJECTIVE	AREA OF IMPACT		
			society	economy	environment
5	Creation of regional institutions for regulation and monitoring	Equitable, productive use of water in the Eastern Nile Basin and ecosystem sustainability as a result of well enforced, transparent and harmonised regulations and monitoring procedures	indirect, but potentially significant	direct, and potentially significant	direct and significant
6	Creation of regional institutions for investments	Reduced transaction costs; streamlined fund management, private sector mobilisation, increased development partner support and riparian cost sharing	direct and significant	direct and significant	indirect
7	Harmonisation of the policy and regulatory framework	Compatible and mutually reinforcing national and regional policy and regulatory frameworks for water resources, agriculture and power development throughout the Eastern Nile Basin	direct and significant	direct and significant	direct and significant
8	Creation of regional institutions for operation and management	Sustainable and productive "basin-level[24]" water management infrastructure performing as per specification	direct and significant	direct and significant	depends on the activity; but potentially direct
9	Joint investment projects	Economies of scale and win-win situations resulting from equitable cost and benefit sharing with respect to "basin-level" infrastructure	indirect	direct and significant	Indirect (in this context)
10	Harmonisation of strategies and projects	International water conflicts avoided as a result of compatible and mutually reinforcing development strategies and consultative project preparation protocols	direct and significant	direct and significant	direct and significant

4.4 Water Development Priorities for the Eastern Nile

4.4.1 Regional Cooperation to Date

After years of talks, Egypt and Sudan signed the Nile water agreement on 8th November 1959. Although this has been regarded by some commentators as a historic achievement because it allocated for the first time the Nile waters between two independent riparian countries, in hindsight it must be acknowledged as a lost opportunity. This is because not only did it completely ignore the interests of the other riparians, it implied and assumption that their interests would never become relevant or significant. This is clearly not the case, to the extent that the 1959 agreement is actually thought of by some of the other riparians as a constraint on equitable management and allocation of the Nile's resources. Notwithstanding this, the 1959 Agreement made possible the immediate construction of the High Aswan Dam (1962-1971), the construction of the Roseires dam (1961 – 1966) and the Managil extension of the Gezira irrigation scheme. It also led to the construction of Khashm El Girba dam and the New Halfa irrigation scheme located on the upper Atbara River in Eastern Sudan where the inhabitants of the Sudanese Nubia were resettled after the inundation of their land caused by the construction of the high Aswan dam.

The agreement also established in Khartoum the Permanent Joint technical Commission (PJTC) composed of renowned hydrologists from both Egypt and Sudan who were charged with planning and executing studies for future conservation projects throughout the Nile basin. Its

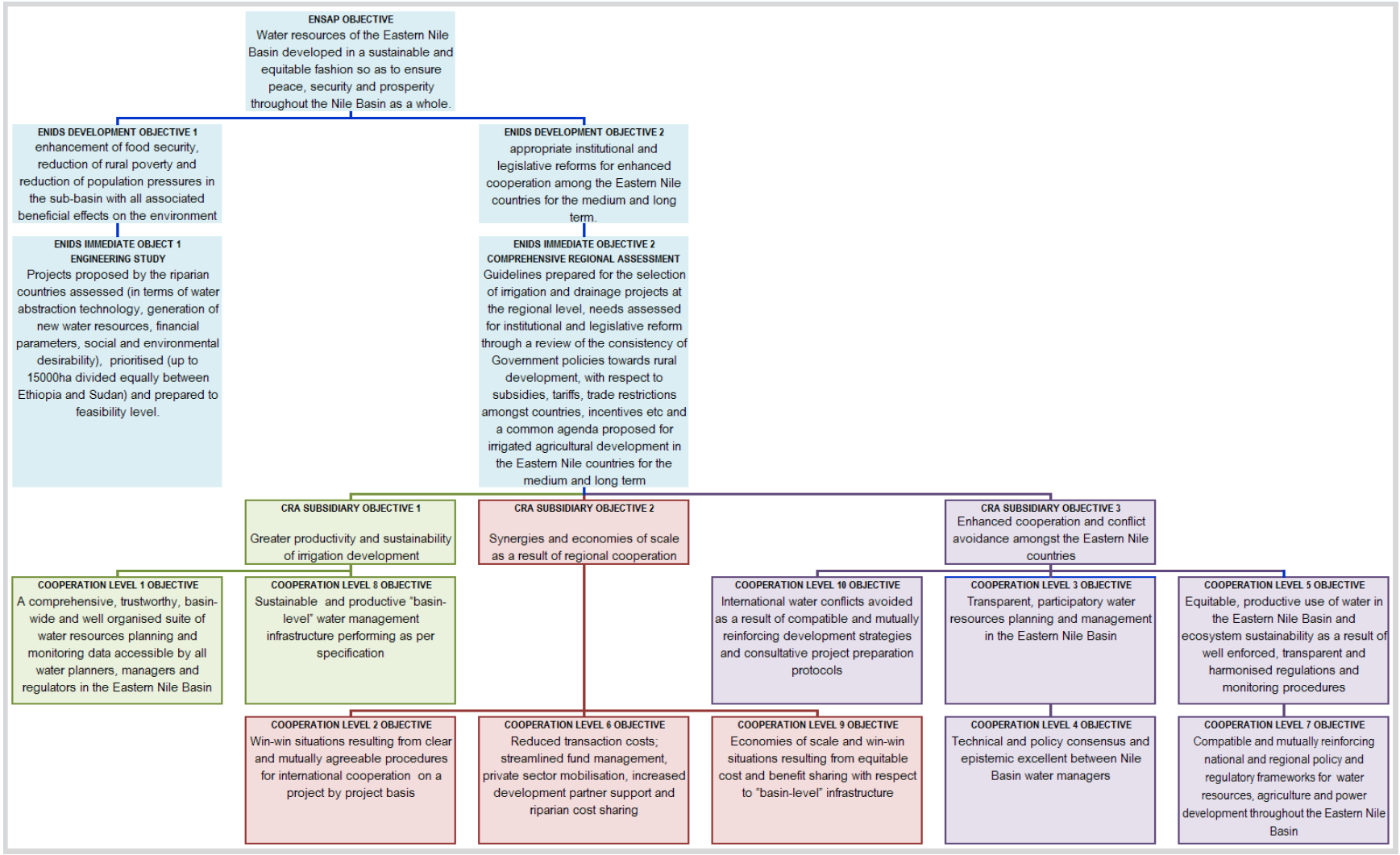
24 By this is meant water development or management infrastructure that benefits more than one of the riparian countries. Examples could be i) a dam constructed for hydro-power generation in Ethiopia that also stores water for irrigation purposes in Sudan and Egypt, or ii) a drainage channel in Sudan that frees up water for irrigation in Egypt.

members were convinced that the future of Nile control lay in devising the means to bring water from the equatorial lakes to Aswan. Strangely, the Blue Nile which provides 84% of the water at Aswan was not included in their grand plan.

The solution adopted by Egypt and Sudan since had not changed since the beginning of the twentieth century: namely the Jonglei canal formerly known as the "Garstin cut" after the name of the British engineer who made the first study in 1904. The Jonglei canal project involves digging a 300 Km long navigable canal between the confluence of the Sobat River and the White Nile near the town of Malakal and the village of Bor on the Bahr al Jabal thereby diverting up to 30 million m^3 per day of the water entering the Sudd, a gigantic swamp where 50% of the water is lost through evaporation – but which is widely considered to represent a major environmental asset with both biodiversity and local livelihood values. Nonetheless, hydrologists of the PJTC estimated that the canal would deliver 4.7 billion m^3 each year to the White Nile at Malakal - equivalent to 3.8 billion m^3 at Aswan after losses through evaporation along the 2700 km long river course between Malakal and Aswan. The decision to go ahead with the project was accordingly made in 1974. The contract to dig the Jonglei canal was awarded in 1976 to the French construction company "Les Grands Travaux de Marseille" (GTM) with the PJTC acting as the principal consultant. Excavation began in 1978. On 10th February 1984 however, the Sudanese People Liberation Army attacked and demolished the Sobat camp of the GTM halting the canal excavation at Km 267. Analysis of reasons for which the SPLA was determined to stop the canal excavation was far beyond the consultants' mandate and even though although a peace agreement between the government of Sudan and SPLA was signed on in Navaisha, Kenya, it is very unlikely that the conditions to resume the work will be met in the foreseeable future.

In Ethiopia, despite comprehensive studies carried out successively by the USBR (Blue Nile Basin Study Plan, 1964) and BCEOM (Abbay Basin Master Plan, 1999), the Ethiopian Blue Nile waters remain virtually untapped to date. This did not inhibit the determination of the successive Ethiopian governments to stress their country's interest in dam construction and water sharing agreements with downstream countries.

Figure 12: Objectives of Regional Cooperation



Egypt's attitude toward riparian countries began to change in the 1980's. The Egyptian Master Water Plan published in 1981 showed that water was no longer abundant for Egypt's growing population requiring that the country should enter an era of stricter control and management of water for agriculture and other needs: hydropower, navigation, industry and domestic uses. Moreover, the decade 1979 – 1988 was a period of low rainfall and drought on the Ethiopian highlands attributed to El Niño climatic phenomena. The drought peaked in 1984 and despite international aid one million Ethiopians and an unknown number of Sudanese died of famine. Egypt would have suffered commensurately as it had throughout the ages, were it not for the water stored behind the Aswan dam. During that decade the annual Nile flow at Aswan shrunk to 49 billion cubic meters, 42% less than the historic average of 84 billion cubic meters. In March 1987, a symposium at the highest political level of Egypt and Ethiopia was organized at Cairo University, an unprecedented and surprising event given the tension between the two countries at that time. The conclusion of the symposium was that cooperation with upstream riparian countries was essential for the Nile waters control.

The drought continued and in July 1988 Lake Nasser fell to a record low and contained only 38 billion cubic metres out of a maximum capacity of 170 billion. The dam had been generating approx half of Egypt electricity but in 1988 it produced less than 18%. Egypt had to decide whether it would sacrifice water for crops or for hydropower. Fortunately in summer 1988, large quantities of water fell onto the Ethiopian Nile and Tekeze-Atbara watersheds and the drought years ended. However the long drought convinced the Egyptian engineers and hydrologists that the Aswan dam could no longer fully guarantee delivery of sufficient water for the needs of Egypt's growing population. The time had finally come for Egypt to begin a meaningful dialogue with Ethiopia and other riparian countries to protect its vital interest. The Nile Basin Initiative (NBI) provides the framework of this dialogue.

4.4.2 Pressing Needs

4.4.2.1 The 2007 Needs Assessment

One of the NBI deliverables is a Decision Support System, to support investment decision making throughout the basin. By the time of writing, its conceptual design had already been delivered in draft form by the Consultant responsible[25]. The Terms of Reference for the Conceptual Design required its Consultant to undertake a comprehensive needs assessment of each of the NBI member countries and of the two sub-regions (EN and NEL). This was done by means of a structured workshop process, the outputs of which were consolidated and analysed statistically. Table 29[26] shows the concerns raised and ranked by the three Eastern Nile Riparians. The results are highly relevant to this discussion and are highly complementary to the conclusions of the Transboundary Analysis described earlier in this document and summarised for the purposes of this section in Appendix 3.

25 A consortium comprising Hydrophil of Austria, in association with ITAD of the United Kingdom and CEDARE of Egypt.

26 Hydrophil et-al, 2007a

Table 29: Results of the 2007 National Needs Assessment

RANK	COUNTRY		
	Egypt	Ethiopia	Sudan
1	Water resources availability	Irrigation	Water resources availability
2	Water quality	Watershed degradation	Coping with droughts and floods;
3	Optimal utilisation of available water resources	Increased energy demand	Soil/Bank erosion
4	Irrigation	Drought Prediction	Water quality
	Rain fed agriculture	Coping with droughts (and floods)	
	Livestock		
5			Water supply and sanitation
6		Water supply and sanitation	Increased energy demand
7	Coping with droughts	Flood Forecasting and Preparedness	Irrigation
			Rain fed agriculture
8	Coping with floods	Wetlands degradation	
9	Population structure/settlement patterns		Watershed degradation (Destruction of natural forests)
10	Soil/Bank erosion		Wetlands degradation
11	Water supply and sanitation		Flood Forecasting and Preparedness
12	Improving and developing navigation potential		Improving and developing navigation potential
13	Increased energy demand		Aquatic weeds
			Tourism

4.4.2.2 The Nature of the Challenge - Competition and Controversy

As might be surmised from the preceding section, Egypt and Sudan's primary concern is availability of water. Table 29 showed that both of these countries would like to increase their irrigated areas – but not indicated is also Egypt's need for increased water supplies in order to keep salinity at bay in the canals, drains and wells in the Delta and to maintain navigation depths in the Nile. In Ethiopia water availability is not an issue, although increased irrigation was cited as the country's top priority. Increased energy demand is an issue for all three countries; but we know from the USBR and BCEOM studies mentioned above, that Ethiopia is best placed (at least in terms of renewable energy) because of the immense hydropower potential of the Blue Nile. However, without equitable operating rules, some downstream stakeholders have taken the position that storage of water for hydropower in Ethiopia may reduce the availability of water for used downstream in Sudan and Egypt – see below. This perception is not helped by the fact that the Ethiopia Water Sector Strategy (Government of Ethiopia 2001) gives priority to "..*multipurpose projects such as irrigation and power, recognising that joint development of hydropower alone*[27] *is of less advantage to Ethiopia, since it regulates the flow for downstream countries, and it traps sediment giving longer life to downstream dams and reservoirs at the expense of Ethiopia's water structures*."

Nonetheless, there is obvious merit in a current proposal that water stored in reservoirs in the Ethiopian highlands with small Area/Storage ratios will lose a lot less to evaporation than the 10

[27] Underlined in the original document

BCM/yr that is lost at Lake Nasser, due to its considerably lower elevation and higher Area/Storage ratio. In addition, the flow regulation afforded by storage on the scale anticipated by Ethiopia would maintain significant year round flows in the Blue Nile (estimated by some to exceed an annual total exceeding 100 BCM[28]). This would massively increase Sudan's ability to irrigate large areas of land in the cold season, when Blue Nile flows are naturally low, while in addition, navigation would become possible year round.

Equally, noting that coping with floods is a pressing issue for the Sudan, dams upstream in the Blue Nile and in Sobat rivers could go a long way towards flood mitigation and would indeed store much of the sediment that is causing so much trouble in Sudan's irrigation schemes[29]. It is interesting in this regard therefore that the clause quoted above from the Ethiopian Water Strategy (*ibid*) specifically justifies maximising accruable dam benefits to Ethiopia itself because downstream countries would get a collateral benefit from the sedimentation (that eventually would reduce the dams productivity). This however, would not be in the emerging spirit of transboundary cooperation because the sediment itself results from long term anthropogenic watershed degradation in Ethiopia, not from natural geomorphologic processes. With this in mind, Sudan would like to see large scale watershed rehabilitation firmly underway in Ethiopia.

We also note that Egypt's oft repeated wish to see the basins major wetlands modified such that they release more usable water into the Nile system is somewhat at odds with Ethiopia and Sudan's concerns about wetland degradation and indeed with inevitable international pressure to preserve these pristine wetlands as environmental hotspots! Nonetheless when considered in the appropriate light, Egypt's concerns are valid. Expansion of Sudan's irrigated area in the absence of measures to improve the productivity of water already used in the sector (by increasing use efficiency and facilitating re-use for instance) would tie up "new" sources that could be used far more productively if allocated more equitably between possible users and uses. In a closing basin, this kind of problem needs institutional solutions such as demand management modalities and improved service delivery as well as improved infrastructure. Equally, although Egypt recognises the long term value of storing water in Ethiopia, in the absence of flexible and adaptive operating rules (ideally dynamic rules supported by upper catchment remote sensing networks) its water managers see a potential, and catastrophic compromise with respect to Lake Nasser's trans-annual drought mitigation function which requires that it remains full until Ethiopia's new dams are full themselves and operating with agreed multi-functionality.

It will be clear that these challenges and opportunities are very real and perfectly valid, and that all the proposed solutions have merit at least to one or another of the players. But even so, many of them are technically or politically mutually incompatible. The desirability of equitable win-win solutions will therefore be equally clear. And this justifies a radical re-think of the institutional landscape as it pertains to the water resources of the Eastern Nile Basin - hence this sub-component of the ENID Study.

Put another way, each player wants more water (largely for irrigation) and everyone wants more power (for many reasons). They also want less flooding, and Sudan wants less sediment while Egypt has valid concerns about nitrates and other pollutants. The possibilities are either for each to go it alone and incur the risk of strife, conflict and quite possibly, regional insecurity; or for the problems to be faced by cohesive units of regional hydrocrats strengthened and working together within an enabling institutional landscape and mandated to look for win-win solutions and maximised basin welfare.

And that opportunity lies at the very heart of the institutional challenge!

4.5 RESPONDING TO THE CHALLENGE

The institutional challenge emerges from a simple analysis of the objectives of cooperation. Various ways by which to achieve those objectives are suggested and subjected to a multi-criteria analysis below. However, in order to begin the analysis it is useful first to relate the Levels of Cooperation and their objectives to the three objectives of the CRA:

28 Estimate shared with the consultant by several officials met with in Khartoum.

29 While in Khartoum, the consultant was informed that some 70% of the total budget allocation for the water sector is used for de-siltation of hydraulic works!

- Two Levels of Cooperation are concerned with increasing the productivity and sustainability of irrigation and drainage investments, namely:
  - Level 1: information sharing; and
  - Level 8: creation of regional institutions for operation and management
- Three are concerned with synergies and economies of scale
  - Level 2: joint activities on issues of regional interest
  - Level 6: creation of regional institutions for investments; and
  - Level 9: joint investment projects
- Five are concerned with increased cooperation and conflict avoidance:
  - Level 3: dialogue
  - Level 4: creation of a regional professional body; and
  - Level 5: creation of regional institutions for regulation and monitoring
  - Level 7: harmonisation of the policy and regulatory framework
  - Level 10: harmonisation of strategies and projects

However, it is also possible and meaningful to cluster the levels according to an appropriate time frame for the intervention required to achieve the three CRA objectives. The result is shown in Figure 11 which is effectively a time based typology for improved institutional and legislative reforms for enhanced cooperation among the Eastern Nile country water sectors for the short, medium and long term, as per the ENIDS second objective[30].

Figure 13: Typology of Institutional and Legislative Reforms for Enhanced Cooperation

	OBJECTIVES OF THE CRA		
INTERVENTION	Greater productivity and sustainability of irrigation development	Synergies and economies of scale as a result of regional cooperation	Enhanced cooperation and conflict avoidance amongst the Eastern Nile countries
Short Term Institutional Reform and capacity building	**Level 1:** information sharing		**Level 3:** dialogue
			Level 4: creation of a regional professional body
		Level 2: joint activities on issues of regional interest	**Level 5:** creation of regional institutions for regulation and monitoring
Medium Term Convergence of national with basin interests and continued capacity building		**Level 6:** creation of regional institutions for investments	**Level 7:** harmonisation of the policy and regulatory framework
Long Term investments	**Level 8:** creation of regional institutions for operation and management	**Level 9:** joint investment projects	**Level 10:** harmonisation of strategies and projects

Having established now established a suitable typology, it is next necessary to assess the reality as it is currently encountered in the Region's existing and planned institutional arrangements. In other words, how close to the typology are the current and/or planned arrangements?

30 As with the multi-criteria analysis, stakeholders are encouraged to review this typology, especially with respect to the allocation of the levels to the time slices.

4.6 An Overview of Existing Arrangements and the Views of Key Stakeholders

This section compares the institutional challenge with a simple synthesis of i) an overview of the existing arrangements (described more fully in Appendix 4); ii) the views of such stakeholders that it proved possible to meet with during the mission in both Ethiopia and Sudan and iii) the results of the situation assessment resulting from the NBI's recently completed Conceptual Design of the Nile Basin Decision Support System (Hydrophil *et-al*. 2007b.).

4.6.1 Historic Agreements and Resulting Arrangements

Of the 18 transboundary agreements and treaties signed since the first was signed on April 15th 1891, only two would seem to of direct relevance to the Eastern Nile in one way or another:

- The November 8th 1955 Nile Waters Agreement (between the governments of Egypt and the Sudan) ; and
- The July 1st 1993 Framework for General Co-operation Between the Arab Republic of Egypt and Ethiopia

The first of these agreements has resulted in the establishment, in the Sudan, of the Joint Permanent Technical Committee which involves Egypt and the Sudan and remains fully functional. In addition there are two other on-going multi-lateral agreements of relevance being negotiated by all the Nile basin countries which are of major importance to the NBI-DSS. These are:

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

And of course, there is also the Nile Basin Initiative which was established in 1999 with the agreement of the Council of Ministers of Water Affairs of the Nile Basin States.

4.6.2 The Nile Basin Initiative and its Relevant Programmes

As mentioned earlier (Section 1.1) the Nile Basin Initiative is a transboundary regional partnership project among the ten Nile Basin riparian countries. The NBI seeks to develop the river in a cooperative manner, sharer substantial socio-economic benefits and promote regional peace and security. It started with a participatory process of dialogue among the riparians that resulted in their agreeing on a shared vision with a participatory process of dialogue among the riparians that resulted in their agreeing on a shared vision: to "achieve sustainable socio-economic development through the equitable utilisation of, and benefit from, the common Nile Basin Water Resources", and a Strategic Action Programme to translate this vision into concrete activities and projects.

To this end, NBI members have developed a so-called Strategic Action Program (SAP) to translate the overall vision into tangible activities and projects; it has two elements:

- The first element is the ***Shared Vision Program*** (SVP) which is focusing on basin-wide projects intended to (i) build trust across the basin; (ii) build capacity within the countries; and (iii) create an enabling environment for implementing development projects. SVP components projects foster an integrated and comprehensive approach to water resources development and management, and serve as catalysts for broader socioeconomic development, including poverty reduction, economic growth, and environmental protection. SVP presently has a coordinated program of eight projects:
  - Applied Training
  - Confidence-Building and Stakeholder Involvement
  - Efficient Water Use for Agriculture
  - Nile Transboundary Environment Action
  - Regional Power Trade
  - Shared Vision Projects Coordination
  - Socio-economic Development and Benefits Sharing
  - Water Resources Planning and Management

- The second element is a suite of Investment Programs agglomerated at the sub-basin level[31] as Sub-regional ***Subsidiary Action Programs*** (SAPs), focusing on sub-basin projects[32] to deliver development projects involving two or more countries. In addition to this (ENIDS) project, the Eastern Nile Subsidiary Action Program (ENSAP) includes:

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

4.6.3 Dialogue and Information Sharing

It is clear from the above that a range of mechanisms for dialogue and information sharing are already in place. These are both formal and informal and it would be wrong to suggest that they are not working. Nonetheless, the usefulness of such arrangements that do exist seems to depend on who is using them.

Some officials in the Sudan for instance, feel that significant progress had been made with respect to information sharing with both Egypt and that increasing progress is being made with respect to Ethiopia. Equally, they feel that since the establishment of the NBI, dialogue has greatly improved. Even so, several commentators, still in the Sudan, stressed that, even though Ethiopian master plans are available to them (a significant gain) periods of notification for specific works remain too short to be of much use; but these same individuals were eager to stress the great improvements with respect to the availability of real time hydrological and climate data and expressed satisfaction with progress being made with respect to the One-System Inventory that is being set up by the NBI.

By way of contrast however, *other* officials in Sudan perceive no real improvements. One official for instance complained that flood warnings were only provided by Ethiopia six hours in advance of the peak, and furthermore, that Sudan's estimates from models using real time satellite data are so inconsistent with the flows that actually occurring that they are suspicious of the transparency of Ethiopia's information! Equally, they complained that although there is discernable improvement with respect to both information and dialogue, there remains a great deal of improvement that could and must be made.

Ethiopia's position is slightly different in that although in absolute (as compared to political) terms they could call all the shots, they see great advantage in working with the downstream riparians and see a pressing need for improved sharing of information with Sudan. This particular opinion is particularly relevant to estimates given to the consultant while in the Sudan, with respect to the benefits of Blue Nile regulation. The Sudanese estimate, at 120 MCM/day, was complete news to the Ethiopians, who by way of response expressed an eagerness to know which data the Sudanese used in making this estimate – as a prelude to working with them on refining this, and other estimates like it.

4.7 Assessment of Current Arrangements

It will be clear that many of these initiatives are relevant to one or other of the levels of cooperation listed in Table 30. As yet however, few represent formalised and empowered institutional arrangements of the sort needed to face the kind of challenges and to seize the kind of opportunities suggested by sub-section 4.6.2.

Table 30 is an attempt to compare these levels with the existing situation. It shows clearly that there are opportunities at every level of cooperation, even where the NBI is already active. The next Part of this document takes a look at what has been done elsewhere.

31 The Eastern Nile (EN) and the Nile Equatorial Lakes (NEL) sub-basins

32 The ENSAP and NELSAP respectively

Table 30: Existing Situation With Respect to the Levels of Cooperation

LEVEL OF COOPERATION		CURRENT STATUS
1	Information Sharing	Improving, especially since the establishment of the NBI
2	Joint activities on issues of regional interest	Several in progress or about to begin under the aegis of the NBI: – Applied Training – Confidence-Building and Stakeholder Involvement – Efficient Water Use for Agriculture – Nile Transboundary Environment Action – Regional Power Trade – Shared Vision Projects Coordination – Socio-economic Development and Benefits Sharing – Water Resources Planning and Management – The Eastern Nile Planning Model Project (ENPM) – The Watershed Management Project – The Ethiopia-Sudan Transmission Interconnection Project – The Flood Preparedness and Early Warning Project – The Baro-Akobo Multi-Purpose Water Resources Development – The Eastern Nile Power Trade Investment Program Study – The Joint Multi-Purpose Program.
3	Dialogue	Improving, especially since the establishment of the NBI
4	Creation of a regional professional body (for water managers and associated technocrats)	Nothing in place
5	Creation of regional institutions for regulation and monitoring	Nothing in place, although the NBI could eventually be responsible for this and indeed would seem to be moving towards such a role
6	Creation of regional institutions for investments	Nothing in place
7	Harmonisation of the policy and regulatory framework	Nothing in place, although it reasonable to suggest that there is emerging goodwill in this respect.
8	Creation of regional institutions for operation and management	Nothing in place
9	Joint investment projects	Nothing at the investment stage as yet, but several initiatives are at the identification or planning stage, including: – Eastern Nile Irrigation and Drainage Project – Eastern Nile Regional Power Trade Investment Programme (which although being originally predicated purely on power generation, is now being considered from a multi-purpose perspective) – Integrated Watershed Management Project – Eastern Nile Flood Preparedness and Early Warning Project (which includes investments in early warning systems); and – Various investments under the JMP
10	Harmonisation of strategies and projects	Nothing in place, although it reasonable to suggest that there is emerging goodwill in this respect.

SECTION 3: REVIEW OF EXPERIENCE ELSEWHERE

4.8 INTRODUCTION

Many transboundary rivers are already or are becoming regulated, managed and developed by organisations established under the terms of agreements or conventions between some or all of the riparians concerned. Appendix 5 lists all such entities established between 1815 and 2002 and shows that they range from full-on basin organisations that include every riparian state and address wide range of issues, through sub-basin entities that address limited ranges of issues, to bilateral arrangements that have been established to address only one.

Although it is fair to say, that in many cases, progress to date has been limited to the formalisation of and commitment to various processes, the various agreements and conventions nonetheless provide a very helpful indication of what others have considered necessary, practical and politically affordable.

The sections which follow attempt to identify emerging best practice with respect to the levels of cooperation introduced in section 4.5 above, using examples drawn from Appendix 5. Table 31 lists these examples: the selection is not exhaustive, neither is it limited to success stories.

Table 31: River Basin Institutions or Agreements Studied

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	STATUS	COMMENTS
Lake Chad			
Cameroon (1964)	Lake Chad Basin Commission	Established by the Fort Lamy Convention in 1964	The Commission's original objectives were the regulation and planning of water use within the basin. However drought response predominated its activities in the early years
Niger (1964)			
Nigeria (196')			
Chad (1964)			
Central African Republic (1994)			
Danube			
Austria	Convention on Cooperation for the protection and Sustainable Use of the Danube River (aka Danube River Protection Convention)	Signed in 1994, but did not come into effect until 1998	The main objective of the Danube River Protection Convention (DRPC) is to ensure that surface waters and groundwater within the Danube River Basin are managed and used in a sustainable and equitable manner. This involves:
Bosnia Herzegovina			
Czech Republic			
Germany			
Hungary			• the conservation, improvement and rational use of surface waters and groundwater • preventive measures to control hazards originating from accidents involving floods, ice or hazardous substances • measures to reduce the pollution loads entering the Black Sea from sources in the Danube River Basin
Moldova			
Romania			
Serbia			
Slovakia			
Ukraine			
(Lower) Mekong			
Cambodia	Mekong River	Established by the	The Commission's objective is to "cooperate in all fields of

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	STATUS	COMMENTS
Laos	Commission	Agreement on the Cooperation for the Sustainable Development of the Mekong River Commission in 1995	sustainable development, utilisation, management and conservation of the water and related resources of the Mekong Basin including, but not limited to irrigation, hydro-power, navigation, flood control, fisheries, timber floating, recreation and tourism in a manner to optimise the multiple-use and mutual benefits of all riparians and to minimize the harmful effects that might result from natural occurrences and mad-made activities
Thailand			
Vietnam			
Nkomati			
South Africa	Tripartite Interim Agreement	Signed in 2002	High demand for irrigation, followed by industry and urban needs, with hydro-ecological regimes disrupted by the many dams
Swaziland			
Mozambique			
Okavango			
Angola	The Permanent Water Commission on the Okavango River Basin (OKACOM)	Established in 1994, by means of the OKACOM Treaty	"to act as a technical adviser to the contracting parties on matters relating to the conservation and utilisation of water resources in common interest to the Contracting Parties". Key issues concerned the water scarce situation in the upstream riparian and the immense importance of annual flood flows into the inland delta downstream in Botswana
Namibia			
Botswana			
Orange-Senque			
Lesotho	The Lesotho Highlands Water Project	Enabling treaty signed in 1986	Controversial initiative predicated on benefit sharing investments centred on Dams in Lesotho generating power for Lesotho's benefit and regulating water supply for South Africa's: complex projects still under implementation (3 phases to 2021)
South Africa			
Sava			
Bosnia Herzegovina	Framework Agreement on the Sava River Basin	Signed in 2002 and ratified in 2004	The agreement is intended to i) establish an international regime of navigation; ii) establish sustainable water management; and iii) prevent or limit hazards such as floods, droughts, ice, accidents and eliminate and/or mitigate their consequences
Croatia			
Serbia			
Slovenia			
Senegal			
Guinea	Senegal River Development Organisation	Establishing agreement signed in 1972 (Guinea has only observer status).	Consolidates a history of successful collaboration beginning in 1963
Mali			
Mauritania			
Senegal			
Zambezi (1)			
Zambia	Zambezi River Authority	Established in 1987	Objective is "to obtain for the economic, industrial and social development of the two countries, the greatest possible benefit from the natural advantages offered by the waters of the Zambezi river and to improve and intensify the utilisation of the waters for the production of energy and for any other purpose beneficial to the two countries
Zimbabwe			
Zambezi (2)			
Botswana (1987)	Action Plan for the Environmentally Sound Management of the Common Zambezi River System (ZACPLAN)	Adopted in 1987	Largely unsuccessful reportedly due to lack of political and financial support and excessive conditionalities considered to have been imposed by UNEP
Mozambique (1987)			
Tanzania (1987)			
Zambia (1987)			
Zimbabwe (1987)	Zambezi Watercourse Commission	Establishing agreement signed 2004	mandate to promote the "equitable and reasonable utilisation of the Zambezi as well as the efficient management and sustainable management thereof"
Angola (1990)			
Malawi (1990)			
Namibia (1990)			

4.9 EXAMPLES OF LEVELS OF COOPERATION FOR THE SHORT TERM

Table 32 provides examples from nine river basins of ways by which to achieve the levels of cooperation which our Typology suggests for the short term. It will be seen that examples are available for each level except for N° 3 "Creation of a regional professional body".

Table 32: Examples of Level of Cooperation for the Short Term

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE SHORT TERM				
		1	2	3	4	5
		Information Sharing	Joint activities on issues of regional interest	Dialogue	Creation of a regional professional body	Creation of regional institutions for regulation and monitoring
Lake Chad						
Cameroon (1964) Niger (1964) Nigeria (196') Chad (1964) Central African Republic (1994)	Lake Chad Basin Commission	One of the Commission's functions is to assemble, examine and disseminate data on projects prepared by member states	One of the Commission's functions is to undertake major studies within the basin	One of the Commission's functions is to maintain dialogue between the member states		
Danube						
Austria Bosnia Herzegovina Czech Republic Germany Hungary Moldova Romania Serbia Slovakia Ukraine	Convention on Cooperation for the protection and Sustainable Use of the Danube River (aka Danube River Protection Convention)	The Convention commits its members to exchanges of information. In addition, The Danube River Commission which the Convention establishes includes a range of expert groups including one dealing with information management	The convention commits its members to cooperate on a wide range of issues including the prevention, control and reduction of transboundary impacts, water quality, research and development, mutual assistance and early warning	The Convention commits its members to demand driven consultation between members with respect to activities with transboundary implications		The convention requires its members to cooperate on monitoring of inter-alias water quality, emission control, flood forecasting and general water balance. In addition, The Danube River Commission which the Convention establishes includes a range of expert groups including one dealing with monitoring and assessment.
(Lower) Mekong						
Cambodia Laos Thailand Vietnam	Mekong River Commission		The Commission's Council is intended to make "policies and decisions and provide other necessary guidance concerning…joint activities"	Many of the Commission's required activities are predicated on assumed dialogue between its members		

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE SHORT TERM				
		1	2	3	4	5
		Information Sharing	Joint activities on issues of regional interest	Dialogue	Creation of a regional professional body	Creation of regional institutions for regulation and monitoring
Nkomati						
South Africa Swaziland Mozambique	Tripartite Interim Agreement	The agreement is built on a strong and compatible information base	Negotiations pre-signature acknowledged for instance, that environmental concerns were an issue of regional interest	The agreement broadens the negotiating base between the three riparians		
Okavango						
Angola Namibia Botswana	The Permanent Water Commission on the Okavango River Basin (OKACOM)			Principle benefit to date has been "..negotiations and discussions and building trust…"		
Orange-Senque						
Lesotho South Africa	The Lesotho Highlands Water Project					
Sava						
Bosnia Herzegovina Croatia Serbia Slovenia	Framework Agreement on the Sava River Basin					
Senegal						
Guinea Mali Mauritania Senegal	Senegal River Development Organisation		The organisation facilitated joint action with regards to dam construction and their regulation in favour of common navigation interests			The Senegal River Charter (2003) commits the Heads of State and their respective Governments to follow principles and objectives for sustainable development of the river
Zambezi (1)						
Zambia Zimbabwe	Zambezi River Authority					
Zambezi (2)						
Botswana (1987) Mozambique (1987)	Action Plan for the Environmentally Sound Management of the	A common database developed				

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE SHORT TERM				
		1	2	3	4	5
		Information Sharing	Joint activities on issues of regional interest	Dialogue	Creation of a regional professional body	Creation of regional institutions for regulation and monitoring
Tanzania (1987)	Common Zambezi River System (ZACPLAN)	under a component project (ZACPRO 6) is considered to have been a success				
Zambia (1987)						
Zimbabwe (1987)	Zambezi Watercourse Commission					
Angola (1990)						
Malawi (1990)						
Namibia (1990)						

It is immediately clear from this table that these examples fall into three distinct clusters as follows:

- ***Functional Responsibility***, in that the institution itself is directly responsible for maintaining a specific level of cooperation. An example would be the Lake Chad Basin Commission which for instance is intended to "undertake major studies"[33] or "assemble, examine and disseminate data…"
- ***Commitment,*** in that the terms of the institutional arrangements commit their signatories to certain actions. An example would be the Convention on Cooperation for the Protection and Sustainable Use of the Danube River, which commits its members for instance, to "…cooperate on a wide range of issues" or for one or several signatories to respond to demands from another or others for "…consultation…with respect to activities with transboundary implications".
- ***Facilitation,*** in that the institutional arrangements are required neither to undertake directly, nor force their members to cooperate in certain ways, but rather to provide the enabling environment within which ad-hoc measures might thrive. Examples would be the Nkomati Tripartite Interim Agreement which "…broadens the negotiating base between the three riparians" or the Senegal River Development Organisation which is known to have "….facilitated joint action with regards to dam construction and their regulation…".

An obvious facilitational opportunity concerns data and information. Noting that incomplete or unharmonised information and data resources were registered as a concern throughout the entire Nile Basin by participants at the Decision Support System consultation workshops (and indeed as noted by some officials met with by this consultant), it is also helpful to see how this has been addressed elsewhere. Thus we see that the Lake Chad Basin Commission is required to "..assemble, examine and disseminate data on projects prepared by its member states" whereas the Action Plan for the Environmentally Sound Management of the Common Zambezi River System itself resulted in the construction of a successful common data base. By way of contract however, the Nkomati Tripartite Interim Agreement is itself "….built on a strong and compatible information base.

4.10 Examples of Levels of Cooperation for the Medium Term

Table 33 provides examples from three river basins of ways by which to achieve the levels of cooperation which our Typology suggests for the medium term. It can be seen that there would seem to be no examples as yet of regional institutions for investment.

33 The quotation marks refer to mention in the tables, not in the enabling instruments.

Table 33: Examples of Level of Cooperation for the Medium Term

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE MEDIUM TERM	
		6	7
		Creation of regional institutions for investments	Harmonization of the policy and regulatory framework
Danube Austria Bosnia Herzegovina Czech Republic Germany Hungary Moldova Romania Serbia Slovakia Ukraine	Convention on Cooperation for the protection and Sustainable Use of the Danube River (aka Danube River Protection Convention)		The convention requires harmonization of emission standards
Sava Bosnia Herzegovina Croatia Serbia Slovenia	Framework Agreement on the Sava River Basin		The Agreement specifically calls for harmonization of national regulations (with the broader regulatory framework of the EU)
Senegal Guinea Mali Mauritania Senegal	Senegal River Development Organisation		Regulatory issues were necessarily harmonized in order to achieve win-win benefits from the investments, and more lately to protect environmental interests

As with the creation of regional institutions for investments, there are no examples of policy harmonisation. There are nonetheless three examples of harmonised regulatory frameworks and each has its own distinctive characteristics. The Convention on Cooperation for the Protection and Sustainable Use of the Danube River for instance is specific and internal in that it requires harmonisation (only) of emission standards. The Framework Agreement on the Sava River Basin on the other hand has external ramifications and is general in that it specifically requires "…harmonisation of national regulations.." but in line with higher level externalities in the form of the "…broader regulatory framework of the EU). Finally, it would seem that regulatory issues can be harmonised as a re-requisite for investment, rather than from a purely operational perspective, as in the case of the Senegal River Development Organisation.

4.11 Examples of Levels of Cooperation for the Long Term

Table 34 provides examples from eight river basins of ways by which to achieve the levels of cooperation which our Typology suggests for the long term. It can be seen that there are examples of each level of cooperation.

Table 33: Examples of Level of Cooperation for the Long Term

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE LONG TERM		
		8	9	10
		Creation of regional institutions for operation and management	Joint investment projects	Harmonization of strategies and projects
Lake Chad Cameroon (1964) Niger (1964) Nigeria (196') Chad (1964) Central African Republic (1994)	Lake Chad Basin Commission		One of the Commission's functions is to plan, coordinate and implement projects of a regional nature	One of the Commission's functions is to recommend plans of action with respect to projects prepared by member states
Danube Austria Bosnia Herzegovina Czech Republic Germany Hungary Moldova Romania Serbia Slovakia Ukraine	Convention on Cooperation for the protection and Sustainable Use of the Danube River (aka Danube River Protection Convention)			The Danube River Commission which the Convention establishes includes a range of expert groups including one dealing with strategy
(Lower) Mekong Cambodia Laos Thailand Vietnam	Mekong River Commission		The Commission's Council is intended to make "policies and decisions and provide other necessary guidance concerning….joint projects…"	The Commission is required to support and coordinate, while cooperating in the development of - *inter-alias* - joint and/or basin wide projects and programmes
Nkomati South Africa Swaziland Mozambique	Tripartite Interim Agreement		There was a history of joint investment between South Africa and Swaziland, the agreement expands the opportunity for "package deals" that now include Mozambique. Furthermore, the agreement sets out principles for cooperation on predicated on the conceptualization of the basin's water as shared resource, with equitable sharing of benefits accruing to increases in supply made possible by dams etc	
Orange-Senque Lesotho South Africa	The Lesotho Highlands Water Project	The Lesotho Highlands Water Commission is responsible and accountable for water transfers and hydropower generation.	South Africa is responsible for the water delivery infrastructure (95% of total costs) while Lesotho the dams (5%)	
Sava Bosnia Herzegovina Croatia Serbia Slovenia	Framework Agreement on the Sava River Basin			The Agreement specifically calls for the creation and realisation of joint plans for the basin and for the development of programmes at basin level

RIVER BASIN	INITIATIVE/ENABLING INSTRUMENT	COOPERATION LEVELS RELEVANT TO THE LONG TERM		
		8	9	10
		Creation of regional institutions for operation and management	Joint investment projects	Harmonization of strategies and projects
Senegal Guinea Mali Mauritania Senegal	Senegal River Development Organisation		Rigorous, highly equitable cost and benefit sharing with respect to the basin level infrastructure (dams, which are owned in common by the three signatories - i.e. not including Guinea as yet))	The Senegal River Charter (2003) commits the Heads of State and their respective Governments to develop the river on the basis of an integrated management strategy.
The Zambezi (1) Zambia Zimbabwe	Zambezi River Authority	The ZRA is responsible for the operation of the Kariba Dam		Kariba Dam is operated in conjunction with other power stations in both countries

Examples of institutional arrangements for cooperation scheduled by our typology for the longer term fall into five distinct categories, which are not necessarily mutually exclusive:

- ***(Actual) Planning, (or the provision of planning recommendations),*** in that the institution itself is directly responsible for the planning function. An example would again be the Lake Chad Basin Commission which is required to "…plan… projects of a regional nature[34] …", and in the case of national infrastructure to "…recommend plans of action…", in order that they might be harmonious.
- ***(Actual) Coordination and Guidance,*** in that the institution does not actually prepare the plans, but rather ensures that they are prepared an implemented from a basin wide perspective. An example would be the Mekong River Commission which is responsible for providing "…necessary guidance for joint projects…" and for coordinating "…joint and/or basin wide projects and programmes". Another example would be the Danube Convention which establishes "…expert groups.." including one dealing with strategy.
- ***Commitment,*** in that the terms of the institutional arrangements commit their signatories to certain actions. An example would be the Framework Agreement on the Sava River Basin which commits its members to the "creation and realisation…of programmes at the basin level.
- ***Joint Investments,*** which is self-explanatory with examples such as the Lesotho Highlands Water Project or dams constructed by the Senegal River Development Authority.
- ***Joint Operation and Maintenance,*** which again is self-explanatory, with examples such as the Kariba Dam which is operated by the Zambezi river authority or once again the Lesotho Highlands Water Project.

4.12 RELEVANCE TO THE EASTERN NILE

Given the context and background established in section 4.6 above, it will be clear that the brief analysis set out above confirms that - with the exception of a regional body for water sector professionals and a regional institution for investment - there is a range of generic approaches that could be applied to the Nile Basin in respect of the proposed levels of cooperation. For the exceptions, new ground may have to be broken.

34 **i.e. what are sometimes called basin-level infrastructure**

SECTION 4: POSSIBILITIES FOR THE EASTERN NILE

4.13 INTRODUCTION – THE ANALYTICAL FRAMEWORK

The typology established in section 4.7; the assessment of the current situation as summarised in table 31; the generic processes emerging from Section 3 along with bespoke processes for the Eastern Nile together suggest a range of *Processes for Cooperation* aimed at the sustainable and equitable development of the Eastern Nile's freshwater resources. A preliminary list of such processes was developed by the consultant and offered to the stakeholders for comments, suggestions and eventual discussion at a workshop convened in Khartoum from the 23rd to 25th August 2008. With the exception of an opinion expressed with respect to the value or validity of expanding the Joint Permanent Technical Committee to include Ethiopia, the list was accepted as offered. And since, no consensus was reached with respect to a rejection of the process by which Ethiopia joins the JPTC; it has been retained, with apologies to the dissenting parties. The results are listed in the last column of Table 35, which reflects a framework that follows the typology set out in 11 above.

Table 35: Possible Processes for Enhanced Cooperation

TIME FRAME	LEVEL		APPLICATION	PROCESS
Short Term	1	information sharing	no change at the national or regional level	no action
			adaptation of existing arrangements at the national level	NBI facilitates information sharing between EN signatories
				Improved informal sharing of information between the EN Riparians on a bi-lateral basis
			adaptation of existing arrangements at the regional level	NBI is given functional responsibility to manage information resources
Short term	1		adaptation of existing arrangements at both levels	Membership of NBI commits signatories to share information
			new arrangements at the national level	Riparian states establish formal bi-lateral information sharing commitments
			new arrangements at the regional level	A new regional institution responsible for the collation, management and dissemination of data and information
			new arrangements at both levels	A new regional institution to facilitate collation, management and dissemination of data and information between the EN riparians
	2	joint activities on issues of regional interest	no change at the national or regional level	no action
			adaptation of existing arrangements at the national level	Stakeholders to individual activities of regional interest commit to joint action on an ad-hoc basis
			adaptation of existing arrangements at the regional level	Expansion of the NBI Joint Multi-Purpose Programme
			adaptation of existing arrangements at both levels	Expansion of the Joint Permanent Technical Committee to include Ethiopia

TIME FRAME	LEVEL		APPLICATION	PROCESS
			new arrangements at the national level	Formal bi-lateral institutions that commit stakeholders to cooperate on activities of regional interest
			new arrangements at the regional level	A convention committing all three riparians to cooperate on issues of regional interest
			new arrangements at both levels	Not relevant
	3	dialogue	no change at the national or regional level	No action
			adaptation of existing arrangements at the national level	NBI facilitates dialogue between EN signatories
				Improved informal dialogue between the EN Riparians on a bi-lateral basis
			adaptation of existing arrangements at the regional level	NBI is established as a regional forum to facilitate increased dialogue
			adaptation of existing arrangements at both levels	Membership of NBI commits signatories to dialogue
			new arrangements at the national level	Riparian states establish formal bi-lateral dialogue fora
			new arrangements at the regional level	A new regional forum for the facilitation of dialogue
			new arrangements at both levels	A new regional institution to moderate dialogue between the EN riparians
	4	Creation of a regional professional body	no change at the national or regional level	Since no such body exists at present, there is nothing to leave unchanged, neither is there anything to adapt.
			adaptation of existing arrangements at the national level	
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
Short term	4		new arrangements at the national level	Not relevant
			new arrangements at the regional level	A regional professional body
			new arrangements at both levels	Not relevant
	5	Creation of regional institutions for regulation and monitoring	no change at the national or regional level	Not relevant
			adaptation of existing arrangements at the national level	
			adaptation of existing arrangements at the regional level	NBI takes on a more specific regulatory and monitoring function
			adaptation of existing arrangements at both levels	NBI guides and consolidates national regulatory and monitoring activities
			new arrangements at the national level	Not relevant
			new arrangements at the regional level	A convention committing signatories to regulation and monitoring of a/o water quality and quantity issues
			new arrangements at both levels	A new regional institution to guide and

TIME FRAME	LEVEL		APPLICATION	PROCESS
				consolidate national regulatory and monitoring activities
Medium Term	6	Creation of regional institutions for investment	no change at the national or regional level	Since no such institution exists at present, there is nothing to leave unchanged, neither is there anything to adapt.
			adaptation of existing arrangements at the national level	
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
			new arrangements at the national level	Not relevant
			new arrangements at the regional level	A Regional Development Bank for the Water Sector
			new arrangements at both levels	Not relevant
	7	Harmonisation of the policy and regulatory framework	no change at the national or regional level	No action
			adaptation of existing arrangements at the national level	since there is currently no harmonisation of the policy and regulatory framework, there are no arrangements to adapt
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
			new arrangements at the national level	Not relevant
			new arrangements at the regional level	Harmonisation of the policy and regulatory framework at the sub-basin level
				Harmonisation of the policy and regulatory framework throughout the entire Nile Basin
			new arrangements at both levels	Not relevant
Long Term	8	Creation of regional institutions for operation and maintenance	no change at the national or regional level	Since no such institution exists at present, there is nothing to leave unchanged, neither is there anything to adapt.
			adaptation of existing arrangements at the national level	
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
			new arrangements at the national level	Not relevant
			new arrangements at the regional level	Institutions established for specific infrastructural facilities
				A single institution responsible for the operation and maintenance of all basin level infrastructure
			new arrangements at both levels	Not relevant
	9	Joint investment projects	no change at the national or regional level	No action
			adaptation of existing arrangements	since there are no current joint investment

TIME FRAME	LEVEL		APPLICATION	PROCESS
			at the national level	projects there are no arrangements to adapt
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
			new arrangements at the national level	Bespoke arrangements for specific investments
			new arrangements at the regional level	A convention committing signatories to the joint creation and realisation of basin level projects
				Regional cooperation on a project by project basis
			new arrangements at both levels	Not relevant
	10	Harmonisation of strategies and projects	no change at the national or regional level	since there are no arrangements for harmonising strategies and projects there is nothing to leave unchanged
			adaptation of existing arrangements at the national level	since there is currently no formal harmonisation of strategies and projects, there are no arrangements to adapt
			adaptation of existing arrangements at the regional level	
			adaptation of existing arrangements at both levels	
			new arrangements at the national level	Bilateral institutions to guide and coordinate national strategies and programmes
				Sector specific bi-lateral arrangements
			new arrangements at the regional level	A basin level apex body to guide and coordinate all water sector strategies and plans
				Sector specific institutions to guide and coordinate basin wide strategies and programmes
				A convention committing signatories to the joint creation and realisation of basin level strategies and projects
Long term	10		new arrangements at both levels	A general basin level institution to guide and coordinate national plans
				Sector specific institutions to guide and coordinate national strategies and programmes

4.14 THE MULTI-CRITERIA FRAMEWORK

It will be recalled from Table 27 above that the multi-criteria framework adopted by the Consultant comprises a suite of criteria, weighting factors for the scores given to each criterion and a rational range of scores appropriate to each criterion.

The criteria themselves were proposed during the Inception Phase and their inclusion in the final version of the Inception Report suggests that they were found agreeable to all concerned. This was confirmed at the Khartoum workshop allowing the criteria to be taken up unchanged for use in this analysis – Table 36 below refers. Before proceeding to it however it is necessary to describe i) how the weighting factors were derived, and ii) the rationale behind the scoring ranges.

It was considered desirable to establish the weighting factors by means of highly consultative process. Accordingly, as a first step, various stakeholders were consulted directly and invited first to rank the criteria in order of perceived importance. Of course, a simple ranking of the criteria would mean, in weighting terms, that the first of six criteria would be six times as important as the last and this (as confirmed by the stakeholders) would be unlikely. The second step therefore required the stakeholders to judge how much more important, in percentage terms, they thought that highest ranking criterion was than the lowest. For each individual consulted the inverse of the ranking values were then distributed equally across the resulting range. The same process was then followed by participants at the Khartoum workshop and weighting factors finally adopted comprised the average of all the results. The referring table 37 was developed from 34 separate rankings. It is interesting to note that in terms of their perceived relevance, the final ranking of the weighted criteria differs from that resulting from the first step, only in terms of the 2nd ranking criteria which originally ranked 3rd and the 3rd which originally ranked second. All others ranked the same at both stages of the exercise. This suggests a reassuring degree of consensus.

Rationale for the allocation of scores scoring ranges is explained on Table 35, which comprises the MCA scoring sheet.

Table 36: Proposed Criteria and Selection of the Weighting Factors

CRITERIA		WEIGHTING FACTOR
1	Will the proposed level and process contribute to increased productivity and efficiency of irrigation projects and generate economies of scale by capturing potential synergies amongst institutions?	0.350
2	Will the proposed level and process result in a distribution of benefits that is acceptable to all concerned Governments and other stakeholders of the Eastern Nile?	0.334
3	Will the proposed level and process be sustainable?	0.336
4	How quickly will benefits accrue to the proposed level and process?	0.469
5	How equitably will the costs of the proposed level and process be shared between the three countries?	0.242
6	How dependant on external assistance will the proposed level and process make the stakeholders?	0.195

4.15 THE MULTI-CRITERIA ANALYSIS ITSELF

The scoring system for the Multi-Criteria Analysis is set out in Table 37.

Table 37: Scoring System for the Multi-Criteria Analysis

CRITERIA	WEIGHTING FACTOR	INDICATORS/RANGE OF SCORES <<<Unfavourable favourable>>>					SCORE GIVEN	WEIGHTED SCORE
Will the proposed level and process contribute to increased productivity and efficiency of irrigation projects and generate economies of scale by capturing potential synergies amongst institutions?		0 means not at all, 4 means that both economies of scale and synergy is achieved						
	0.350	0	1	2	3	4		0
Will the proposed level and process result in a distribution of benefits that is acceptable to all concerned Governments and other stakeholders of the Eastern Nile?		This is largely qualitative and is scored according to the judgement of the scorer						
	0.334	1	2	3	4	5		0
Will the proposed level and process be sustainable?		0 means not at all, 4 means that the Process is highly sustainable						
	0.336	0	1	2	3	4		0
How quickly will benefits accrue to the proposed level and process?		5 is immediate, 1 is later than 2012 (when the current phase of the NBI is due to end)						
	0.469	1	2	3	4	5		0
How equitably will the costs of the proposed level and process be shared between the three countries?		This is largely qualitative and is scored according to the judgement of the scorer						
	0.242	1	2	3	4	5		0
How dependant on external assistance will the proposed level and process make the stakeholders?		length of time that external support is required for 0 is always, 4 is never						
	0.195	0	1	2	3	4		0
							TOTAL	0

As with the weighting factors, scoring for the Multi-Criteria Analysis was also carried out in two steps. The first of these simply involved the Consultant who, using the first set of weighting factors, scored the processes independently of the stakeholders. The second step was to use the final weighting factor and have the processes scored by the stakeholders at the Khartoum workshop, working in four groups, each of which included representatives of each of the three EN countries. The remainder of this section is concerned with the second step results. However, at the request of the workshop, these are analysed in comparison with those resulting from the first step, and where significant differences occur, and again at the request of the workshop, the Consultant's final recommendation is offered.

Table 38 therefore reproduces Table 35 but has an additional column presenting the scores from the Multi-Criteria Analysis as carried out by participants at the Khartoum workshop. Details of how these scores were derived is provided in Appendix 6; but it should be understood i) that scores may change as time progresses, not least because that of the agreed criteria, those with a temporal emphasis (i.e. the fourth criteria) do not (yet) vary with the time scale - this is something for the future; and ii) that scores should not be seen as a ranking tool for the entire suite of processes because they do not all address the same objective (and as we saw above in section 4.5, the processes are themselves have no meaningful ranking). That being said, where they do address the same objective, i.e. for each level of cooperation, the rankings are highly relevant in that they identify the most favourable process.

Table 38: Results of the Multi-Criteria Analysis

TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Short Term	1	information sharing	adaptation of existing arrangements at both levels	Membership of NBI commits signatories to share information	5.42
			adaptation of existing arrangements at the regional level	NBI is given functional responsibility to manage information resources	4.91
			new arrangements at both levels	A new regional institution to facilitate collation, management and dissemination of data and information between the EN riparians	4.46
			adaptation of existing arrangements at the national level	NBI facilitates information sharing between EN signatories	3.94
			new arrangements at the regional level	A new regional institution responsible for the collation, management and dissemination of data and information	3.82
			new arrangements at the national level	Riparian states establish formal bi-lateral information sharing commitments	3.73
			no change at the national or regional level	no action	3.18
			adaptation of existing arrangements at the national level	Improved informal sharing of information between the EN Riparians on a bi-lateral basis	3.07
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Short Term	2	joint activities on issues of regional interest	adaptation of existing arrangements at the regional level	Expansion of the NBI Joint Multi-Purpose Programme	6.04
			new arrangements at the regional level	A convention committing all three riparians to cooperate on issues of regional interest	5.56
			adaptation of existing arrangements at both levels	Expansion of the Joint Permanent Technical Committee to include Ethiopia	5.39
			adaptation of existing arrangements at the national level	Stakeholders to individual activities of regional interest commit to joint action on an ad-hoc basis	4.11
			no change at the national or regional level	no action	3.61
			new arrangements at the national level	Formal bi-lateral institutions that commit stakeholders to cooperate on activities of regional interest	3.38
			new arrangements at both levels	*Not relevant*	

TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Short Term	3	dialogue	adaptation of existing arrangements at the regional level	NBI is established as a regional forum to facilitate increased dialogue	6.32
			new arrangements at the regional level	A new regional forum for the facilitation of dialogue	5.99
			adaptation of existing arrangements at both levels	Membership of NBI commits signatories to dialogue	5.84
			adaptation of existing arrangements at the national level	NBI facilitates dialogue between EN signatories	3.53
			new arrangements at both levels	A new regional institution to moderate dialogue between the EN riparians	2.61
			no change at the national or regional level	No action	2.49
			adaptation of existing arrangements at the national level	Improved informal dialogue between the EN Riparians on a bi-lateral basis	2.12
			new arrangements at the national level	Riparian states establish formal bi-lateral dialogue fora	1.39
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Short Term	4	Creation of a regional professional body	new arrangements at the regional level	A regional professional body	7.12
			no change at the national or regional level	*Since no such body exists at present, there is nothing to leave unchanged, neither is there anything to adapt.*	
			adaptation of existing arrangements at the national level		
			adaptation of existing arrangements at the regional level		
			adaptation of existing arrangements at both levels		
			new arrangements at the national level	*Not relevant*	
			new arrangements at both levels	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Short Term	5	Creation of regional institutions for regulation and monitoring	new arrangements at both levels	A new regional institution to guide and consolidate national regulatory and monitoring activities	6.46
			new arrangements at the regional level	A convention committing signatories to regulation and monitoring of a/o water quality and quantity issues	5.36
			adaptation of existing arrangements at the regional level	NBI takes on a more specific regulatory and monitoring function	4.65
			adaptation of existing arrangements at both levels	NBI guides and consolidates national regulatory and monitoring activities	4.56
			no change at the national or regional level	*Not relevant*	
			adaptation of existing arrangements at the national level		

			new arrangements at the national level	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Medium Term	6	Creation of regional institutions for investment	new arrangements at the regional level	A Regional Development Bank for the Water Sector	6.84
			no change at the national or regional level	*Since no such institution exists at present, there is nothing to leave unchanged, neither is there anything to adapt.*	
			adaptation of existing arrangements at the national level		
			adaptation of existing arrangements at the regional level		
			adaptation of existing arrangements at both levels		
			new arrangements at the national level	*Not relevant*	
			new arrangements at both levels	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Medium Term	7	Harmonisation of the policy and regulatory framework	new arrangements at the regional level	Harmonisation of the policy and regulatory framework throughout the entire Nile Basin	7.94
			new arrangements at the regional level	Harmonisation of the policy and regulatory framework at the sub-basin level	6.50
			no change at the national or regional level	No action	3.49
			adaptation of existing arrangements at the national level	*since there is currently no harmonisation of the policy and regulatory framework, there are no arrangements to adapt*	
			adaptation of existing arrangements at the regional level		
			adaptation of existing arrangements at both levels		
			new arrangements at the national level	*Not relevant*	
			new arrangements at both levels	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Long Term	8	Creation of regional institutions for operation and maintenance	new arrangements at the regional level	A single institution responsible for the operation and maintenance of all basin level infrastructure	4.65
			new arrangements at the regional level	Institutions established for specific infrastructural facilities	2.17
			no change at the national or regional level	*Since no such institution exists at present, there is nothing to leave unchanged, neither is there anything to adapt.*	
			adaptation of existing arrangements at the national level		
			adaptation of existing arrangements at the regional level		

			adaptation of existing arrangements at both levels		
			new arrangements at the national level	*Not relevant*	
			new arrangements at both levels	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Long Term	9	Joint investment projects	new arrangements at the regional level	A convention committing signatories to the joint creation and realisation of basin level projects	7.42
			new arrangements at the regional level	Regional cooperation on a project by project basis	5.65
			new arrangements at the national level	Bespoke arrangements for specific investments	4.16
			no change at the national or regional level	*there are no current joint investment projects*	
			adaptation of existing arrangements at the national level	*since there are no current joint investment projects there are no arrangements to adapt*	
			adaptation of existing arrangements at the regional level		
			adaptation of existing arrangements at both levels		
			new arrangements at both levels	*Not relevant*	
TIME FRAME	LEVEL		APPLICATION	PROCESS	MCA SCORE
Long Term	10	Harmonisation of strategies and projects	new arrangements at the regional level	A basin level apex body to guide and coordinate all water sector strategies and plans	8.10
			new arrangements at the regional level	A convention committing signatories to the joint creation and realisation of basin level strategies and projects	7.28
			new arrangements at the national level	Bilateral institutions to guide and coordinate national strategies and programmes	5.34
			new arrangements at both levels	Sector specific institutions to guide and coordinate national strategies and programmes	5.12
			new arrangements at the regional level	Sector specific institutions to guide and coordinate basin wide strategies and programmes	4.83
			new arrangements at both levels	A general basin level institution to guide and coordinate national plans	4.72
			new arrangements at the national level	Sector specific bi-lateral arrangements	4.43
			no change at the national or regional level	*since there are no arrangements for harmonising strategies and projects there is nothing to leave unchanged*	
			adaptation of existing arrangements at the national level	*since there is currently no formal harmonisation of strategies and projects, there are no arrangements to adapt*	
			adaptation of existing arrangements at the regional level		
			adaptation of existing arrangements at both levels		

4.16 Comparison of the First and Second Rounds of Scoring and Final Selection of Processes

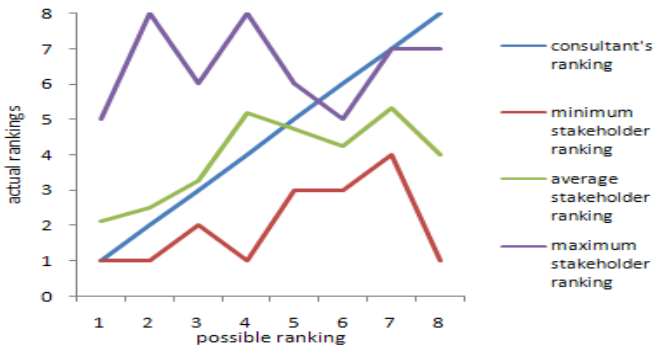
Table 39 compares the scores resulting from the Consultant's first attempt at the Multi-Criteria Analysis with those resulting from the more participatory second round. It does this by showing the rankings achieved by each process within its level of cooperation, since however, levels 4 and 6 only have single processes, the comparison is only possible with the remaining 8.

Table 39: Rankings resulting from the Multi-Criteria Analysis

MCA RANKINGS resulting from:								
STEP 1	STEP 2							
1	1	1	1	2	2	2	3	5
2	1	1	1	2	2	2	3	8
3	2	2	3	3	3	4	6	
4	1	4	6	7	8			
5	3	4	6	6				
6	3	4	5	5				
7	4	5	7					
8	1	7						

Thus the first row indicates how the process ranked first by the consultant fin each of the eight levels of cooperation was ranked by the workshop participants. It can be seen that in three cases, the participants also ranked that process first, in three cases second and one case each, third and fifth. An almost identical agreement was obtained with the Consultant's second ranking process. Figure 12 is a graphical representation of the same data.

Figure 14 Graphical Representation of Table 39



Consideration of the table and the chart together, confirms that where the Consultant ranked a particular process first, second or third, the workshop participants also ranked it thus, or largely within one step of the Consultant's ranking. This indicates a high degree of consensus between Consultant and stakeholder. However, as the number of possible processes decreases then the differences become bigger. This is not explained simply by the fact that the limited choices make it more difficult to obtain a close "average" as for the first three. For these, it is not just that the averages that are close, but also that a significant number of the participants own rankings either tally with that of the Consultants, or are within one step of it.

Lower order discrepancies of course, are not a reason for concern. This is because by definition a multi-criteria analysis is intended to identify the best, not the worst options to work with.

With all this in mind, it is possible to define a rationale for final selection of the processes thus:

- where the participants' and Consultant's first ranked processes are the same then that process is obviously selected
- where the participants' first ranked process is no more than one step different from the ranking given to the same process by the Consultant; then, unless there is an overarching technical reason for sticking with the Consultant's choice[35], the participants' is adopted

[35] An eventuality which did not, in fact, arise.

These two possibilities cover 6 of the 8 levels of cooperation having more than one possible process.

The first of the two levels of cooperation that exhibit significant differences between the Consultant and the workshop participants is the first, i.e. Information Sharing. For this, the Consultant had concluded that "A new regional institution responsible for the collation, management and dissemination of data and information" would be ideal. However, the participants ranked this process fifth, preferring instead that"Membership of NBI commits signatories to share information". The Consultant, even though ranking this last, is happy to defer to the participants' choice in consideration of the aptness and convenience of an NBI based solution.

The second discrepancy concerned level five "Creation of regional institutions for regulation and monitoring". Whereas the Consultant selected "A convention committing signatories to regulation and monitoring of a/o water quality and quantity issues", the participants ranked this second, preferring instead "A new regional institution to guide and consolidate national regulatory and monitoring activities", which the Consultant ranked fourth. Again, after due consideration the Consultant is happy to defer to the participants choice.

Table 40 therefore lists the final selection.

Table 40 Selected Institutional Processes for Enhanced Regional Cooperation

TIME FRAME	LEVEL		OBJECTIVE	PROCESS
Short Term	1	information sharing	A comprehensive, trustworthy, basin-wide and well organised suite of water resources planning and monitoring data accessible by all water planners, managers and regulators in the Eastern Nile Basin	Membership of NBI commits signatories to share information
	2	joint activities on issues of regional interest	Win-win situations resulting from clear and mutually agreeable procedures for international cooperation on a project by project basis	Expansion of the NBI Joint Multi-Purpose Programme
	3	dialogue	Transparent, participatory water resources planning and management in the Eastern Nile Basin	NBI is established as a regional forum to facilitate increased dialogue
	4	Creation of a regional professional body	Technical and policy consensus and epistemic excellent between Nile Basin water managers	A regional professional body
	5	Creation of regional institutions for regulation and monitoring	Equitable, productive use of water in the Eastern Nile Basin and ecosystem sustainability as a result of well enforced, transparent and harmonised regulations and monitoring procedures	A new regional institution to guide and consolidate national regulatory and monitoring activities
Medium Term	6	Creation of regional institutions for investment	Reduced transaction costs; streamlined fund management, private sector mobilisation, increased development partner support and riparian cost sharing	A Regional Development Bank for the Water Sector
	7	Harmonisation of the policy and regulatory framework	Compatible and mutually reinforcing national and regional policy and regulatory frameworks for water resources, agriculture and power development throughout the Eastern Nile Basin	Harmonisation of the policy and regulatory framework throughout the entire Nile Basin
Long Term	8	Creation of regional institutions for operation and maintenance	Sustainable and productive "basin-level" water management infrastructure performing as per specification	A single institution responsible for the operation and maintenance of all basin level infrastructure
	9	Joint investment projects	Economies of scale and win-win situations resulting from equitable cost and benefit sharing with respect to "basin-level" infrastructure	A convention committing signatories to the joint creation and realisation of basin level projects

TIME FRAME	LEVEL		OBJECTIVE	PROCESS
	10	Harmonisation of strategies and projects	International water conflicts avoided as a result of compatible and mutually reinforcing development strategies and consultative project preparation protocols	A basin level apex body to guide and coordinate all water sector strategies and plans

SECTION 5: CONCLUSIONS AND RECOMMENDATIONS

4.17 CONCLUSIONS OF THE INSTITUTIONAL ASSESSMENT

Recalling the nature of the challenge and the assessment of current arrangements as set out in sections 4.6.2.2 and 4.9 respectively, it is both interesting and relevant i) to acknowledge that the current situation remains less than satisfactory and ii) to note the kinds of application that the selected processes (table 40) refer to. It will be remembered that seven possible applications were assumed for the purposes of this analysis. These were:

- no change at the national or regional level
- adaptation of existing arrangements at the national level
- adaptation of existing arrangements at the regional level
- adaptation of existing arrangements at both levels
- new arrangements at the national level
- new arrangements at the regional level
- new arrangements at both levels

Table 41 shows i) that only four of these applications are relevant to the ten processes finally selected, and, ii) that each concerns either a new arrangement at the regional level, adaptation of existing arrangements at the regional level, new arrangements at both levels or adaptation of existing arrangements at both levels. Regional initiatives are therefore involved in every one of the ten processes and furthermore, the need for new or adapted regional arrangements predominates. It can safely be concluded therefore that a regional approach is the only basis for an institutional strategy towards improved water management and productivity in the Eastern Nile basin.

Table 41 Relevant Applications for Institutional Processes

APPLICATION	LEVEL		PROCESS
new arrangements at the regional level	4	Creation of a regional professional body	A regional professional body
	6	Creation of regional institutions for investment	A Regional Development Bank for the Water Sector
	7	Harmonisation of the policy and regulatory framework	Harmonisation of the policy and regulatory framework throughout the entire Nile Basin
	8	Creation of regional institutions for operation and maintenance	A single institution responsible for the operation and maintenance of all basin level infrastructure
	9	Joint investment projects	A convention committing signatories to the joint creation and realisation of basin level projects
	10	Harmonisation of strategies and projects	A basin level apex body to guide and coordinate all water sector strategies and plans
adaptation of existing arrangements at the regional level	2	joint activities on issues of regional interest	Expansion of the NBI Joint Multi-Purpose Programme
	3	dialogue	NBI is established as a regional forum to facilitate increased dialogue
adaptation of existing arrangements at both levels	1	information sharing	Membership of NBI commits signatories to share information
new arrangements at both levels	5	Creation of regional institutions for regulation and monitoring	A new regional institution to guide and consolidate national regulatory and monitoring activities

4.18 IMPLEMENTATION OF THE SELECTED PROCESSES

The participatory nature of the approach used for the institutional analysis and the generally high multi-criteria scores given to most of the selected processes confirms that each of them can be considered desirable, according to the opinion of the stakeholders. Beyond that it is not meaningful to claim that one is more desirable than another because each is targeted at a different objective. It may be argued of course that one objective may be more desirable than another; but since all of the objectives are subsidiary to higher level objectives, it would be somewhat counterproductive to rank the objectives. Better is to consider the entire suite of processes as an integrated institutional approach for improved water productivity and management in the basin.

Nonetheless, practicality and political reality suggests that it would be wise not to attempt the more difficult processes too soon. In other words, stakeholder buy-in and functional success are more likely to accrue if the processes scheduled for the short and even medium term either build on existing arrangements or are perceived as politically affordable. This wording has been chosen carefully, because none of the processes can be considered controversial from a technical point of view, again because they were developed in a participatory manner. Even so, the need to expend political capital will be inevitable in some cases. This of course will be easier to do, if the more "costly" processes follow on from other, "cheaper" ones that are already up, running and demonstrably effective.

The time based typology comprising Figure 13 was based purely on technical considerations. Given, the need also for early success, it is necessary to assess the extent to which the selected processes do indeed build on existing arrangements, or are not likely to be politically expensive.

Obviously these considerations are of most importance in the *short term*.

The typology specifies five levels of cooperation that need to be addressed or initiated in the short term. Three of these all build on a single existing entity, namely the Nile Basin Initiative thus:

- For Level 1 – information sharing – the selected process simply commits NBI signatories to improved sharing of information between each other.
- For Level 2 – joint activities on issues of regional interest – the selected process simply calls for expanded coverage of an ongoing initiative.
- For Level 3 – dialogue – the selected process simply requires that the NBI expands its remit such that it can facilitate increased dialogue between its members.

None of these processes represents a significant departure from the NBIs existing activities, from its "business-as-usual" as it were.

- For Level 4 – creation of a regional professional body – the only possible process is that one is created. Since there are minimal to nil political ramifications here, it is potentially a simple matter for the professionals themselves to incorporate such a body. That being said, funding will no doubt have to be identified and it may be necessary for the governments concerned to agree the charter and articles of association of any professional body. But again, the political exposure will be minimal.
- For Level 5 – creation of regional institutions for regulation and monitoring – the selected process may present a degree of political difficulty if one country is reluctant to be regulated by another. But it is reasonable to expect that the improved dialogue, activities of regional interest and the professional consensus achieved by the regional professional body will all facilitate smooth establishment of the regulatory entity. With this in mind, it is suggested however, that its establishment is scheduled for latte end of the short term.

For these reasons the consultant concludes that everything specified for the short term will be found to be politically acceptable while presenting no significant technical difficulties with respect to implementation.

As far as the *medium term* is concerned, things become a little more challenging.

- For level 6 – creation of regional institutions for investment – the selected process calls for the creation of a regional bank. Unless the capitalisation is to be an entirely regional affair, there will be the problem of identifying and attracting other shareholders, and this in turn will require demonstration of adequate capacity for both investment cycle management and fiduciary risk management. That being said however, it is known that wealthy countries in the Middle East have already expressed interest in financing water sector investments in the Eastern Nile. China is also positioning itself as a potential financier in the basin. If such "declared" donors can be persuaded with respect to the desirability of whatever degree of autonomy would be vested in the regional bank, then such an entity well may become a reality. Even so, the degree of success achieved in the short term will be an obvious criterion for any potential donor/shareholder.
- For Level 7 – harmonisation of the policy and regulatory framework – the selected process requires that this is done throughout the basin. At present this would seem problematic because of the conflicting interests and priorities described earlier in section 4.6.2. Nonetheless there are encouraging signs. The NBI is proving itself as a neutral body, while Egypt's calls for optimization studies on new basin level infrastructure suggests that the possibilities of win-win-win scenarios are becoming increasingly. But it will take sound leadership on the part of the NBI and each country's professionals if any momentum gained towards consensus during the short term, is to result in a harmonised policy and regulatory framework. Nonetheless, as shown in Section 3, there are examples in river basins elsewhere that prove it can be done – if the political will is there.

Finally, there is the *long term*. It is entirely concerned with investments and should present no difficulties of the short and medium terms are successful.

- For Level 8 – creation of regional institutions for operation and maintenance – the selected process, a single institution for the operation and maintenance of all basin level infrastructures should be a logical follow-on from transboundary investments and should in fact be an obvious outcome of any distributive analysis of said investments.
- For Level 9 – joint investment projects – the selected process is simply the establishment of a convention committing signatories to the joint creation and realisation of basin level projects and as such would be an obvious adjunct to the legal instruments incorporating the regional bank called for in the medium term (on which this process would not actually be dependent). In addition, there are promising examples of such conventions in force in basins elsewhere.
- For Level 10 – harmonisation of strategies and projects – the selected process, namely a basin level apex body to guide and coordinate all water sector strategies and plans is not very different from the NBI which is already in place. By the time that this function is required, the NBI should have evolved from an initiative, accountable to each member country, to a commission (or equivalent) to the authority of which, the riparians defer on water allocation, management, development and quality issues.

All in all therefore, it is reasonable to conclude that the strategy suggested by the participatory institutional analysis will be largely straightforward, with the exception of three rather more challenging processes (regional institutions for regulation and monitoring, a regional development bank for the water sector and harmonisation of the regulatory and policy frameworks). These challenges are not insurmountable, especially given the momentum accruing to the initiatives already in progress and which will accrue to the less challenging processes. In any case, no-one has said that river basin management is challenge free. The challenges identified above can be faced successfully and will have to be if improved water management and productivity are to be sustained at the regional level.

There is no reason therefore to recommend anything other than adoption of the complete institutional strategy, implementation of which will be significantly facilitated by the considerable usefulness as institutional pilots, of the transboundary projects described in Part IV which follows, and its supporting appendices, two of which take a closer look at their relevance in this context.

5. Part V Proposed project profiles and distributive analysis

5.1 TRANSBOUNDARY IRRIGATION DEVELOPMENT PROJECTS

5.1.1 Introduction

Among the findings of the ENIDS Component 2, a Phase 2 analysis has been the identification of several potential transboundary irrigation development zones (IDZs). Two of them span the Ethiopian/Sudanese border, namely:

IDZ 3 which concerns the Blue Nile and its Rahad and Dinder tributaries; and
IDZ 4 which concerns the Tekeze and Atbara sub-basins.
In IDZ 3, relevant irrigation projects are:

Rahad (45,100 Ha) and Galegu (9,900 Ha) projects both in Ethiopia and dependant on a dam across the Rahad river
Lower Dinder (50,000 Ha) also in Ethiopia, but dependant on a dam across the Dinder River
Rahad 2 (210,000 Ha) in Sudan, and currently predicated on a plan to harvest water from the Dinder and Rahad rivers by means of dams across each river along with a link canal joining Dinder and Rahad rivers complementing Blue Nile water diverted from the Roseires dam.

Naturally, development of irrigation upstream in Ethiopia would reduce water availability for Rahad 2 project as presented in Table 42.

Table 42: Rough calculation of water availability in Dinder & Rahad Rivers.

	Rahad R	Dinder R
Current annual flow to Sudan (Mm^3)	1 000	2 200
Water requirement of Rahad project, Ethiopia (Mm^3)	501	
Water requirement of Galegu project, Ethiopia (Mm^3)	106	
Water requirement of Lower Dinder project, Ethiopia (Mm^3)		560
Annual flow to Sudan after completion (Mm^3)	393	1 640

In IDZ 4, relevant irrigation projects are:

- Humera (43,000 Ha) in Ethiopia and dependant on a dam across the Tekeze River (or Setit River as it is known in Sudan)
- Angereb (16,500 Ha) in Ethiopia and dependant on a dam across Angereb River a tributary of Atbara River and
- Metema (11,600 Ha) in Ethiopia and dependant on a dam across Goang River (or Atbara River as it is known in Sudan)
- Upper Atbara project (99,000 Ha) in Sudan and the existing New Halfa project (180,000 Ha) both on Atbara River in Sudan. The Upper Atbara project assumes the construction of two dams, first the Rumela dam on the Atbara river just upstream of its confluence with the Setit river and at a later stage a dam on the Setit river to supply water both for the new irrigation project and the New Halfa project as Khashm El Girba dam is now almost silted up.

As in IDZ 3, irrigation development in Ethiopia will also reduce water availability for projects in Sudan, although in a much smaller proportion, see Table 43. It must be noted here that the feasibility study of the Humera project is ongoing and that an upstream dam on the Tekeze River is now completed.

Table 43: Rough calculation of water availability in Tekeze-Atbara sub basin (MCM)

	ANGEREB & GOARG/ATBARA RIVERS	TEKEZE/SETIT RIVERS	TOTAL
Current annual flow at Shuwak, Sudan	5 000	7 500	12 500
Annual requirement of Humera Project		920	
Annual requirement of Angereb Project	223		
Annual requirement of Metema Project	107		
Annual inflow to Sudan after project completion	4 670	6 580	11 250

Source: Upper Atbara feasibility study

5.1.2 Rationale: A transboundary approach of irrigation development

In many respects, competition for water in IDZ's 3 and 4 is representative of the Eastern Nile basin as a whole where irrigation development has usually so far been envisaged in an unilateral manner. But cooperative, transboundary approaches to water management and utilisation have the potential to i) reduce investment costs through economies of scale on infrastructure construction (and massively so where one dam could do the job of two or more) and ii) increase irrigation benefits through regional trade and iii) testing levels and processes of regional cooperation on a pilot scale prior to taking them to scale, adapting them or building on them at the level of the Eastern Nile Basin as a whole. More generally a feasibility study of transboundary irrigation projects would also determine mechanisms of regional cooperation regarding water management and dam operation, research and extension services and capacity building activities for irrigation staff and farmers organizations; hence these specific transboundary irrigation projects would serve as a "real world" test for processes and levels of cooperation for later adoption at the Eastern Nile basin level.

5.1.3 Description of the Project

Objectives

The study will to the irrigation sector goals of the participating countries, Ethiopia and Sudan through an integrated approach to irrigation and drainage development in IDZs 3 & 4. It will also serve as a test for processes and levels of cooperation for future adoption at the Eastern Nile basin level. The specific objectives of the study are:

Determine the "best bet" option regarding investment in irrigation development within a regional perspective and verify the potential for economy of scale in terms of water storage infrastructure; for instance with appropriate levels of water storage upstream in Ethiopia, water storage needs in Sudan would be reduced;

Optimization of operation of existing and planned dams in IDZs 3 & 4 to maximize benefits of irrigation and secure reliability of water supply under any natural hydrological circumstances.

Establishment of regional institutional arrangements for joint water management

Develop regional trade for maximizing benefits of irrigation development.

Activities

Component 1: Technical studies

Sub-component 1.1: Diagnostic

a) Determination of water storage needs and arrangements in each IDZ: construction of dams and/or intervention on existing dams
b) Determination of constraints in terms of minimum annual flow in the dry season for water users other than irrigation (domestic, livestock, industry, environmental flow)
c) Determination of the maximum total irrigable area and selection of irrigation schemes to be constructed
d) Analysis of downstream impacts, mainly attenuation of flood, sedimentation capture, water supply at Aswan.
e) Analysis of hydropower production.

Sub-component 1.2: Feasibility studies

Feasibility studies of proposed dams and irrigation schemes with a particular respect to on-farm water use efficiency, reuse of drainage water, conjunctive use of water, control of water quality.

Component 2 economic study

a) Calculation of economic and financial indicators net surplus value and economic internal rate of return
b) Distribution of costs and benefits per sector (irrigation, hydropower) and country

Component 3: Institutional development study

a) Propose the principles and procedures for allocating water between the Ethiopia and Sudan and between the various users (irrigation schemes) and sector (irrigation and hydropower).
b) Propose principles and procedures for joint operation and maintenance of dams
c) Propose procedures and regulations for water quality preservation and monitoring
d) Propose a framework for water user participation in water resource management decision making processes, in particular respect for variability of natural hydrological circumstances.
e) Propose legislation changes for facilitating cross boarder marketing of products

5.2 IRRIGATION MODERNIZATION PROJECT

5.2.1 Rationale

There are seven main reasons why modern irrigation technologies for large scale schemes in the Eastern Nile basin are required:

All Eastern Nile countries want to transfer irrigation management to farmers controlled organizations at least at the lower level of the irrigation systems. It is now widely recognized that many of the disappointing results of irrigation management transfer in the developing world eventually stem from difficulties with both management and technologies. Modernization of technologies thus corresponds to the need to increase productivity by increasing control over flow in irrigation systems.

Irrigation is by far the major water user in the Eastern Nile basin. With increasing water scarcity and increasing competition with other users (municipal and industrial uses), modern technologies are required for high irrigation water use efficiency in irrigation systems

The project of building a cascade of dams across the Abbay River in Ethiopia is a major opportunity for regulating and optimizing flow of the Eastern Nile. This demands technology for flow control, monitoring and measurement and coordinating operation of all dams in the Eastern Nile river system.

The present stock of large scale irrigation infrastructure in Sudan is aging and some of the schemes are reaching the end of their economic life. Difficulty of maintenance in the past has contributed to the deteriorating conditions of the schemes. Simple repairs would not be sufficient to enable the schemes to respond to the challenge of greater water productivity.

Ethiopia and Sudan want to increase irrigation contribution to food production. Since vertical expansion of irrigation is limited by water availability, most of the increased production will have to come from high yields and high cropping intensity. This implies adoption of modern irrigation technologies for improved water control in the design of new irrigation schemes or the rehabilitation of existing ones.

The rising costs of energy will increase the cost of pumping, hence the need for more efficient use of energy for irrigation.

ICID has started a debate on the top technologies than can meet the challenge of producing 67% more food on irrigated land over the next 25 to 30 year with only a moderate increase in water use. Some of the proposed technologies relate to agronomy and agricultural practices and out of the realm of this project. The remaining top priorities are all relevant and could be used as guidelines:

- Farmer controlled water supply, or total channel control or downstream control of canals.
- Emitter delivery systems for precision irrigation and for undulating terrain, not just through drip systems but also through centre pivots with sweeps programmed to serve typical farm blocks. Such technologies can bring irrigation to areas previously thought capable only of purely rain-fed production.
- Wetting front indicator, a technology recognised for its outstanding potential for improving on-farm water management but not yet widely appreciated.
- Drain controllers for their capability to improve control of soil moisture and stimulate sub-irrigation.
- Remote sensing coupled with computers and /or cell phone for control, measurement and monitoring of water use in large irrigation systems.

- Drainage for improving agricultural productivity, flood control and salinity control which is so much needed in Sudan irrigation schemes. Drainage can also help with health (prevention of water borne diseases).

In addition to the above, optimization of dams operation under any natural hydrological circumstances is a top priority for the Eastern Nile basin. It is reinforced by the fact that dams operation will have to respond to climate change. Predictions converge that the weather pattern will become more variable and include more extreme events.

5.2.2 Description of the project

Objectives

- Improving the hardware for greater flow control and measurements in irrigation canals technology and allow service oriented irrigation management
- Improving the design and rehabilitation of large irrigation and drainage systems with a basin perspective: on-farm water use efficiency, reuse of drainage water, conjunctive use of water, control of water quality.
- Efficient use of energy in irrigation
- Facilitating adoption of software technology in large scale irrigation schemes (electronics, communication and computer systems) including SCADA (Supervisory Control and Data Acquisition).

Activities

Activities of the project include:

- Analysis of large scale irrigation performance in the Eastern Nile basin to facilitate application of lessons learned and transfer of experience;
- Inventory of technologies available worldwide including an inventory of digital technologies and lessons learned on application;
- Mapping of technology needs throughout the Eastern Nile basin
- Data base and best practice inventory on design and rehabilitation for service oriented irrigation management and maximization of farmers' control;
- Data base and best practice inventory on design and rehabilitation of I&D schemes in the Eastern Nile basin context: on-farm water management, conjunctive use of water, reuse of drainage water, monitoring of water quality.
- Data base and best practice inventory on energy conservation in irrigation (gravity supply versus low-lift pumping).
- Feasibility study to establish a regional institution in charge of irrigation technology issues, possible functions include
    - Establish and maintain regional networks
    - Organize discussions groups and knowledge synthesis on irrigation technology and other themes that are important in the Eastern Nile.
    - Enrich and maintain knowledge base system and databases
    - Establish and maintain peer review panel preferably consisting of experienced irrigation professionals and recognized researchers of the Eastern Nile countries
    - Produce and publish regional newsletter
    - Design special investigations and pilot studies in the field of technology assessment if the information is not available elsewhere. Implement through special task forces on the basis of financing agreements.
    - Organize workshops and conferences to disseminate results and promote use of appropriate technologies.
    - Link regional research and education institutions with international institutions such as ICID, IWMI, IPTRID preferable through joined work.
    - Others to be determined

- Feasibility studies for design or modernization of selected large scale irrigation schemes in the Eastern Nile countries.

5.3 INSTITUTIONAL IMPLICATIONS OF THE PROPOSED PROJECTS

The study of institutional issues and opportunities associated with the proposed projects (Appendix 5 refers) suggests that the following levels and processes will be necessary for their successful implementation and operation:

LEVEL OF COOPERATION	PROCESS
Information sharing	NBI facilitates information sharing between EN signatories
Joint activities on issues of regional interest	Expansion of the NBI Joint Multi-Purpose Programme
Dialogue	NBI facilitates dialogue between EN signatories
Creation of regional institutions for regulation and monitoring	A convention committing signatories to regulation and monitoring of a/o water quality and quantity issues
Harmonisation of the policy and regulatory framework	Harmonisation of the policy and regulatory framework throughout the entire Nile Basin
Creation of regional institutions for operation and maintenance	Institutions established for specific infrastructural facilities
Joint investment projects	Regional cooperation on a project by project basis
	Bespoke arrangements for specific investments

The same study indicated that these institutional measures are highly relevant to the broader objective of improved water management and productivity at the regional level.

5.4 DISTRIBUTIVE ANALYSIS OF COSTS AND BENEFITS FOR THE PROPOSED PROJECTS

Until detailed quantitative studies have been carried out, it is only possible to describe the distribution of costs and benefits at the level of the principles involved for this Appendix 5 refers.

Capital Costs are distributed on the basis of the Net Present Value of the benefiting infrastructure.

Thus, if the:

- Cost of the shared infrastructure is C
- NPV of the Ethiopian schemes is NPV_{ETH}
- NPV of the Sudanese schemes is $PxNPV_{SUD}$
  where P is the percentage of the schemes that depends on the shared infrastructure

Then the capital costs are distributed as follows:

- ETHIOPIA PAYS

$$\frac{C \times NPV_{ETH}}{(NPV_{ETH} + PxNPV_{SUD})}$$

- SUDAN PAYS

$$\frac{C \times PxNPV_{SUD}}{(NPV_{ETH} + PxNPV_{SUD})}$$

The following presents an example of the calculations for the Tekeze/Atbara Basin. Table 44 shows the salient details for the irrigation schemes and reservoirs to be developed in the basin.

Table 44 Details on potential irrigation schemes and reservoirs in Tekeze/Atbara basin.

Project	River	Purpose of dam	Irrigable area (ha)	live storage (MCM)	GWR (MCM)	IC for irr (MUSD)	O&M costs (MUSD)	O&M costs % of IC	IRR %	NPV at 2% (MUSD)
Irrigation Project				**6)**		**7) 10)**	**10)**		**5)**	
Humera 1)	Tekeze/Setit		43000	na	520	520	5,2	1,0	11,3	906
Angereb 1)	Angereb		16500	na	223	178	1,8	1,0	13,1	385
Metema 1)	Goang/Atbara		11600	na	156	98	1,0	1,0	17,1	308
New Halfa 2)	Atbara		124000	na	1550	891	8,9	1,0	9-10	*1800*
New Half rehab 3)	Atbara		56000	na	700	50	1,3	2,6	na	*800*
Upper Atbara	Atbara		99000	na	1990	712	2,3	1,0	9,0	1457
Reservoir										
Tekeze Dam TK05	Tekeze/Setit	HP/irr	na	*2000*	na	*500*	5	1,0		
Setit Dam	Setit/Tekeze	Irr	na	*2000*	na	*450*	5	1,0		
Rumela Dam 4)	Atbara	Irr	na	1700	na	413	4	1,0		
Angereb Dam TK21 8)	Angereb	Irr	na	*600*	na	*180*	2	1,0		
Goang Dam 9)	Goang/Atbara	Irr	na	*600*	na	*180*	2	1,0		

na = not applicable; HP = hydropower; irr = irrigation
1) 80% of area for commercial farms, 20% for smallholder farms.
2) existing, no rehab, investment costs similar to Upper Atbara cost. 50% of area for commercial farms, 50% of area for smallholders
3) existing, rehab costs estimated at 500 USD/feddan (1999) plus 20% for increase upto 2008
4) 1999 costs +20% for increase upto 2008, excluding M&E equipment for HP and transmission line
5) based on cropping intensities of 150%.
6) values shown in italics are estimates
7) values shown in italics are estimates, based on assumed unit investment costs of 0,2-0,3 USD/m3
8) average volume of regulated flow is 654 MCM
9) average volume of regulated flow is 821 MCM
10) 1 USD = 9.8 ETB; 1 USD = 2.0 SDG

Applying the above mentioned formula's the following results are obtained:

1) The cost of the shared infrastructure which comprise the costs allocated for irrigation to the Tekeze Dam, and Goang and Angereb dams amounts to 860 million USD, if 500 milllion USD of the cost of the Tekeze Dam is allocated to irrigation and 500 million USD to hydropower.
2) The NPV of the Ethiopian projects is 1,600 million USD
3) The NPV of the Sudanese projects in the basin that depend on the shared infrastructure is 4,057 million USD, where as the percentage of the schemes that depend on the infrastructure is 100%.

Hence, the distribution of the capital costs for the dams would be as follows:

1) Ethiopia: 860 x 1,600/(1,600+4,057) = 243 million USD
2) Sudan: 860 x 4,057/(1,600+4,057) = 617 million USD

If it is assumed that the full costs of the Tekeze Dam are allocated for HP only and the livestorage volumes of Goang and Angereb Dams are only sufficient for the Ethiopian projects, then the full costs of the infrastructure is allocated to Ethiopia.

Attention should be given to the fact that the calculations are based on many assumptions and rough estimates. Especially the costs of the dams, their live storage volumes and the rules of allocation of costs to irrigation and hydropower have to be assessed on much more detail. However, this is outside the scope of this report.

Direct Operating Costs are distributed simply by exacting a service charge based on the operation and maintenance costs of supplying water, along with capital depreciation and replacement costs and possible a management fee which would be agreed in advance.

Direct Benefits at the scheme edge do not need to be distributed, because so long as the direct operating costs are paid, neither country is an investor in the other's operation. Direct benefits accruing to added value in the market chain also do not need to be distributed, unless one country is an investor in the other's added value facilities. But in this case, such benefits would be distributed according to each investor's equity position.

Indirect Costs and Benefits again do not need to be distributed unless they arise due to water savings that can be reallocated to another venture in way that reflects the resource price. If or when this occurs the benefits would be distributed in proportion to each country's share of the amount saved.

Induced Costs and Benefits also do not need to be distributed unless they increase the resource price of any water saved by creating additional demand for it. But if this should occur satisfaction of that demand would be a trade like any other and hence the benefits and their distribution would be captured by the same mechanism as the indirect costs and benefits.

6. BIBLIOGRAPHY

GENERAL

1) Comprehensive assessment of water for food, Chapter 5: Reinventing irrigation, M. Svendsen & H. Turral, IWMI (2007).

2) Nourrir la planète (*Feeding the planet*), M. Griffon, Edition Odile Jacob (2006).

3) Elaboration du plan d'action durable du bassin du Niger (*Formulation of the sustainable action plan of the Niger River basin*); Phase I : Diagnostic ; BRLi (2007).

4) Assessment of Irrigation Options; Dr K. Sanmuganathan; the World Commission on Dams (2000).

5) Ostrom, Elinor. *Crafting institutions for self-governing irrigation systems*; Institute for Contemporary Studies. San Francisco, USA (1992).

6) Brl. 2007a. Eastern Nile Irrigation and Drainage Study, Inception Report (revised version.

7) Bruce. 1790. Travels to Discover the Source of the Nile in the years 1768, 1769, 1770, 1771, 1772 and 1773 – Vol I, page 528, Edinburgh.

8) Dombrowski. 2006 Integration in the Management of International Waters: Policy Discourse, Theory Prediction and Empirical Evidence. Paper presented at the International Workshop in Governance and the Global Water System.

9) Elwan 2007. 2007. DSS Baseline Assessment Report. Consultant's Report to the Nile Basin Initiative.

10) Hydrophil et-al. 2007a. Needs Assessment and Conceptual Design of the Nile Basin Decision Support System: Analysis Report - Annex A Needs Assessment. Consultant's Report to the Nile Basin Initiative.

11) Hydrophil et-al. 2007b. Needs Assessment and Conceptual Design of the Nile Basin Decision Support System: Inception Report - Annex A Situation Assessment Report. Consultant's Report to the Nile Basin Initiative.

EGYPT

12) Fertilizers use in Egypt; FAO (2005).

13) Multipurpose Development of the Eastern Nile, One–System inventory report on water resource related Data and information Egypt; Draft report; ENTRO (2006).

14) Country report Egypt; FAO AQUASTAT data (2005).

15) Water control in Egypt's irrigation canals; Peter P. Mollinga and Al; Wageningem Agricultural University, the Netherlands (1998).

ETHIOPIA

16) Ethiopia: Building on Progress; A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10); Volume I Main Text; Ministry of Finance and Economic Development (MoFED) (2006).

17) Abbay River Basin Integrated Development Master Plan, Phase 3 Volume I-Main Report, BECOM and BRGM, 1999.

18) Abbay River Basin Integrated Development Master Plan; Executive Summary, BECOM & BRGM, 1999.

19) Abbay River Basin Integrated Development Master Plan; Phase 3 Pre-feasibility Study, Part 1 Irrigation and Drainage-Gilgel Projects, BCEOM & BRGM, 1998.

20) Abbay River Basin Integrated Development Master Plan; Phase 3 Pre-feasibility Study, Part 3 Irrigation and Drainage- Megech, BCEOM & BRGM, 1999.

21) Abbay River Basin Integrated Development Master Plan; Phase 3 Pre-feasibility Study, Part 4 Irrigation and Drainage- North East Lake Tana, BCEOM & BRGM, 1999.

22) Abbay River Basin Integrated Development Master Plan; Phase 3 Pre-feasibility Study, Part 5 Irrigation and Drainage- Ribb, BCEOM & BRGM, 1999.

23) Abbay River Basin Integrated Development Master Plan; Volume V-Water Resources Part 1 Irrigation & Drainage, BCEOM & BRGM, 1999.

24) Land and Water Resources of the Blue Nile Basin, Appendix VI-Agriculture & Economics, USBR, 1964.

25) Arjo-Didessa Irrigation Project, Feasibility Study-Annexure 10 Irrigation and Drainage, WWD&SE and ITC of India, May 2007.

26) Tekeze River Basin Integrated Development Master Plan Executive Summary, NDECO, 1998,TEKEZE RIVER BASIN INTEGRATED DEVELOPMENT MASTER PLAN, Volume XI Natural Resources, Land Cover/Use, Agriculture, Livestock & Fishery, NDECO, 1998.

27) Tekeze River Basin Integrated Development Master Volume X, Water Resources, WR5 Irrigation, NDECO, 1998.

28) Arjo-Didessa Irrigation Feasibility Study, Main Report WWD&SE with ITC, 2007.

29) Arjo-Didessa Irrigation Project Feasibility Study Volume IV (a to c), Agriculture, WWS & DE with ITC, 2007.

30) Water Resources and irrigation development in Ethiopia; Seleshi Bekele Awulachew and Al; Working paper 123; IWMI (2007).

31) Importance of Irrigated Agriculture to the Ethiopian Economy: Capturing the direct net benefits of irrigation; Fitsum Hagos, IWMI, Sub-regional office in Addis Ababa (2008, not published).

32) Government of Ethiopia. 1999. Ethiopia Water Resources Management Policy. Ministry of Water Resources.

33) Government of Ethiopia. 2001. Ethiopia Water Sector Strategy. Ministry of Water Resources.

34) National DSS Unit – Ethiopia. 2007. Nile Basin Decision Support System Baseline Assessment Final Report. Government Report.

SUDAN

35) Coyne B. Alexander Gibb. Hunting Technical Service 1978. Nile Waters Study. Min. of Irrig. Khartoum. Sudan (1978).

36) Options for sustainable development of the Gezira irrigation scheme; World Bank (2000).

37) Country report Sudan; FAO AQUASTAT data (2005).

38) The Feasibility of integration of livestock production in irrigated agriculture of Sudan (Case study of the Gezira scheme); Raga Mohamed El-Zaki Ali; PhD thesis, University of Khartoum (2005).

39) Upper Atbara dam & irrigation project; Feasibility study main report; SOGREAH (1978).

40) BRLi. 2007a. Eastern Nile Irrigation and Drainage Study, Inception Report (revised version.

41) Government of Ethiopia. 1999. Ethiopia Water Resources Management Policy. Ministry of Water Resources.

42) Government of Ethiopia. 2001. Ethiopia Water Sector Strategy. Ministry of Water Resources.

43) Government of Sudan. 2007a. Country Policy on Integrated water Resources Management. Ministry of Irrigation and Water Resources.

National DSS Unit – Ethiopia. 2007. Nile Basin Decision Support System Baseline Assessment Final Report. Government Report.