Eastern Nile Technical Regional Office (ENTRO)

Eastern Nile Irrigation and Drainage Study (ENIDS)

COMPONENT 1: MAIN REPORT

PHASE 1: DIAGNOSTIC AND PLANNING PHASE

REVISED FINAL VERSION

MCE

BRL Ingénierie

SHORACONSULT Co. LTD

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EASTERN NILE IRRIGATION AND DRAINAGE STUDY
COMPONENT 1: PHASE 1: DIAGNOSTIC AND PLANNING PHASE
MAIN REPORT

Table of contents

List of tables:

List of maps:

List of appendices:

LIST OF ABBREVIATIONS AND ACRONYMS

Fiscal Year:

Egypt: 01 July – 30 June

Ethiopia: 08 July – 07 July

Sudan: calendar year

MEASURES

km	=	kilometre
km^2	=	square kilometre
m	=	metre
m^3	=	cubic metre
mm	=	millimetre
Mm^3	=	million cubic metres
BCM	=	billion cubic metres
1 ha	=	2.38 feddans
1 feddan	=	0.42 hectares

ABBREVIATIONS

AA	Addis Ababa
ADB/F	African Development Bank/Fund
ANRS	Amhara National Regional State
ARBID/MPS	Abbay River Basin Integrated Development Master Plan
BCEOM	Consulting Firm
BCM	Billion Cubic Meters = 1 km^3
BRGM	Consulting Firm
B/C ratio	Benefit Cost ratio
DIU	Dams Implementation Unit (Sudan)
dS/m	deci-Siemens per meter
d/s	downstream

EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMA	Ethiopian Mapping Agency
ENCOM	Eastern Nile Council of Ministers
ENPV	Economic Net Present Value
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
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPMS	Environmental Protection Monitoring Strategy
EWA	Ethiopian Water Authority
FAO	Food and Agriculture Organization
FNPV	Financial Net Present Value
FIRR	Financial Economic Rate of Return
G	Gravity
GOE	Government of Egypt
GFDRE	Government of the Federal Democratic Republic of Ethiopia
GOS	Government of Sudan
GTZ	German Technical Cooperation Agency
Ha	hectare
HP	hydro power
ICCON	International Consortium for Co-operation on the Nile
ICT	Consulting Firm
IEE	Initial Environmental Examination
ISL	Consulting Firm
LUT	Land Utilisation Type
masl	Meters above sea level
MCA	multi-criteria analysis

mcm	Million Cubic Meters
MoIWR	Ministry of Irrigation and Water Resources (Sudan)
MoWR	Ministry of Water Resources (Ethiopia)
NBI	Nile Basin Initiative
NEDECO	Netherlands Engineering Consultants (Consulting Firm)
NELSAP	Equatorial lakes subsidiary action programme
NELT	North East Lake Tana
NGO	Non-Governmental Organization
Nile-SEC	NBI Secretariat
Nile-COM	Nile Council of Ministers
ONRS	Oromia National Regional State
O&M	Operation and Maintenance
P	Pumping
PA	Peasant Association
PF	Pre-feasibility
PFS	Pre-feasibility Study
PMO	Project Management Office
SAP	Subsidiary Action Programmes
SEIA	Social and Environmental Impact Assessment
SVP	the Shared Vision Programme
TAMS	Consulting Firm
TCC	Technical Coordinating Committee
TDS	Total Dissolved Solids
TLU	Tropical Livestock Unit (metabolic weight equivalence)
TOR	Terms of Reference
TTB2	a set of geological formations
UA	Unit of Account
U/s	upstream
USBR	United States Bureau of Reclamation
WAPCOS	Consulting Firm

WB	World Bank
WRMP	Water Resources Management Policy
WUA	Water Users Association
WWD&SE	Water Works Design and Supervision Enterprise

CONVERSION FACTORS

- 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

1. Introduction

1.1 AIM OF THIS REPORT

This report has been prepared in the framework of the Eastern Nile Irrigation and Drainage Study (ENIDS). This Study is implemented by a joint venture of consultants (hereinafter called 'the Consultants') that is made up of the following four firms:

- Three international firms: **BRL (France), DHV (the Netherlands), and SSI (South Africa)** who fill up most of the key staff positions. BRL as the lead consultant is responsible for the overall management of the team and the contact with the client.
- Two regional firms: **Shoura Consult (Sudan) and Metaferia (Ethiopia)**, responsible for field work in their respective country under the supervision of key international staff.

The report presents the results of the Phase 1 Diagnosis Study of Component 1, covering the period end of September 2007 to the end of May 2008. During this phase the Consultants have collected, in close collaboration with ENTRO and the National Coordinators (NCs) studies, maps, drawings, and other relevant information and have reviewed data, available on the relevant GIS databases in Ethiopia and Sudan.

This report is structured as follows:

Chapter 1: Introduction

Chapter 2: Project descriptions

Chapter 3: Cost calculations

Chapter 4: Cost and benefit anlysis

Chapter 5: Multi criteria analysis

This report presents the information that is required to assess values of parameters, that are used in the multi criteria analysis (MCA) to rank projects in the way as described in chapter 5. The multi-criteria analysis is also presented in the report on Phase 2: Analysis of the Cooperative Regional Assessment sub-study (CRA). It is structured as follows:

Part 1: Description of existing irrigation development in the Eastern Nile Basin

Part 2: Challenges and opportunities of irrigation development in the Eastern Nile Basin

Part 3: Distributive analysis

Part 4: Multi-criteria analysis, presentingthe results of the ranking

Part 5: Institutional analysis

1.2 BACKGROUND

1.2.1 SUMMARY OF THE OBJECTIVES OF THE STUDY

The Study aims at contributing to the agricultural sector goals of the participating countries, Ethiopia and Sudan, to an integrated approach to irrigation and drainage development in the Eastern Nile sub-basin as a means for enhancing food security, poverty reduction, improved welfare of the rural population and sustainable natural resource management in the respective countries.

The specific objectives of the study are twofold:

- to ascertain the viability of the projects proposed by the riparian countries in relation to water abstraction technology, generation of new water resources, financial parameters, social and environmental desirability, prioritise them, prepare the most promising ones (with a total area of about 15,000 ha) up to the feasibility level equally divided between Ethiopia and Sudan;
- to prepare guidelines for the selection of Irrigation and Drainage projects at the regional level, assess needs for institutional and legislative reform through review of consistency of respective Governments' policies towards rural development, with respect to subsidies, tariffs, trade restrictions amongst countries, incentives etc., and propose a common agenda on irrigated agriculture development for the Eastern Nile Countries for the medium and long-term.

1.2.2 COMPONENTS OF THE STUDY AND TIMING OF ACTIVITIES

The Study comprises two components :

- I : Engineering sub-study:
  - Inception: the draft and final report were submitted in September 2007 and December 2007 respectively;
  - Phase 1: Diagnosis and planning of activities: to result in identification and proposal of 15,000 ha to be studied at feasibility level; submission of draft report: 1st of June 2008.
  - Phase 2: Feasibility study of 7,500 ha gross in Ethiopia and 7,500 ha gross in Sudan.
- II : Cooperative Regional Assessment sub-study:
  - Phase 1: Inception: the draft and final report were submitted in September 2007 and December 2007 respectively.
  - Phase 2: Analysis: submission of draft report: 1st of June 2008.
  - Phase 3: Finalization and conclusion: expected by the end of October 2008.

The overall implementation schedule as originally proposed in the Inception Report would terminate in mid September 2008. However, due to problems outside the control of the Consultants work on Phase 1 of the Engineering Component could not be started before 1st February. This resulted in a delay of 3.5 months. Phase 2 of the Engineering sub-study will be completed after the results of the field studies have been obtained. The field studies are expected to be carried out during September-December 2008, whereas the feasibility study is expected to be completed by the end of 2009.

1.3 METHODOLOGY FOLLOWED

In line with then ToR this report presents the results of the diagnosis of the listed projects that have been studied and are under study, as well as some new projects that were identified after it was concluded that most of the listed projects were already being studied or have been studied at Feasibility level. The methodology comprises the following:

- Interpretation of the ToR with reference to the situation whereby almost all ToR listed projects have been taken for FS.
- The selection of the projects to be studied and the presentation and analysis of information of these projects.
- The subsequent selection of 15,000 ha for FS.

1.3.1 INTERPRETATION OF TOR

The Contract Agreement mentions the following for Phase 1 of the Engineering Component:

- *The Engineering sub-study will start with a Diagnosis of the existing situation and the Planning of study activities. As part of the Diagnosis, the Consultant will endeavour to have a thorough knowledge of the conditions related to the 747,600 ha of land that have been identified for irrigation development in Sudan, and the 433,706 ha that have been identified for irrigation development in Ethiopia (see annex 2).*

1. Article 2.3, page 8 of the ToR states: *The proposed study areas include 6 potential project sites in Ethiopia and Sudan. Three (3) of these six proposed projects areas are located in Ethiopia: (i) Lake Tana Shore Project, (ii) Humera Irrigation Project, (iii) Nekemt-Didessa Irrigation Project. The other three (3) are located in Sudan: (i) Upper Atbara Development Project, (ii) Great Kenana Irrigation Project, (iii) El Rahad Phase II Project. The project sites details are presented in Annex 2. The acreages presented in Annex 2 amount to about 747,600 ha in Sudan and 433,706 ha in Ethiopia. However, they concern the whole ENSAP program for Irrigation and Drainage. This study will provide, at a preliminary stage, a diagnosis on the total acreage. Following that, the study will cover only part of these areas and will specifically aim at studying a total aggregated area over Ethiopia and Sudan of about 15,000 ha up to feasibility level and 9,000 ha up to detailed preparation. Brief descriptions of the project sites, geophysical and social characteristics are given below. The documents available include essentially river basins Master Plans. The Consultant will be required to collect all information needed, including level of preparation of the various proposed studies, with collaboration of focal persons that will be designated at line ministries in Ethiopia and Sudan.* **The Consultant has analysed all information on the TOR Annex 2 listed projects, that was made available to him upon request. The analysis is presented in project descriptions.**

- *All studies of technical nature (i.e. hydrological, pedological, topographical, geotechnical etc.) or economic nature, master plans for river basin developments, pre-feasibility studies or feasibility studies, maps, aerial photographs, population surveys etc. related to these areas will have to be identified and indexed for possible future use*. **All documents to which access was given are listed in the bibliography at the end of this report. The information collected for the GIS database is presented as Appendix 1 to this report.**
- *As an assessment of the situation on the ground and of available information, the Consultant will review the data and projections contained in the indexed studies or reports*. **The review of the data and projections, taken from the main reports and important annexes will be shown in the project descriptions.**
- *make collection of fresh data as relevant in a campaign of field visits / investigations, and analyze the whole information gathered with a view of making a preliminary determination of sites that would appear technically feasible both for irrigation development and irrigated cropping*. **Relevant fresh data has been collected and analyzed by the consultants in order to update cost and benefits of proposed projects.**

- *On the basis of these collected information, analyses, review of national policies, strategies and priorities, exchanges with potential projects stakeholders during field visits or seminars, the Consultant will identify and propose about 15,000 ha (7,500 ha in each of the two countries) for feasibility studies.* **The information presented in the project descriptions and the GIS data base, the updated cost calculations, and information collected in the field were used to determine the values of indicators of the multi-criteria analysis (MCA).**

1.3.2 SELECTION OF PROJECTS TO BE STUDIED AND PRESENTATION AND ANALYSIS OF INFORMATION

All projects listed in Annex 2 of the TOR were studied and for each of these projects a description was prepared. Moreover, investment and recurrent calculations were made in order to determine cost indicators, to be used in the MCA, presented in chapter 5 of this report.

2. PROJECT DESCRIPTIONS AND WATER REQUIREMENTS

2.1 PROJECT DESCRIPTIONS

During the preparation of the Terms of Reference a total of 6 potential projects and project areas were identified. These are presented as follows (see Map 01 for location):

Ethiopia:

1. Lake Tana Shore Project
2. Humera Irrigation Project
3. Nekemte-Didessa Irrigation Project

Sudan

4. Upper Atbara Development Project
5. Great Kenana Irrigation Project
6. El Rahad Phase II Project.

Table 2.1 shows the proposed IDEN projects as presented in Annex 2 of the Terms of Reference, with potential areas and names as revised by the Consultants. The list includes the new sites that were identified during the study. The revised potential area for each of the projects or project areas has been derived from Masterplan documents and 1:50,000 maps analyses. The project areas cover the following projects (see also table 2.1 for information on status of studies:

- The Lake Tana&Beles Subbasin: Megech Gravity (dam dependent), Megech Pumping (construction is about to start), Ribb Dam&Irrigation (construction of the dam has already started), Gumara Dam&Irr Projects, Gilgel Abbay schemes, NELT, Delgi&Kunzila&Zege, South West Tana, Upper&Lower Beles.
- The Didessa Sub basin projects: Arjo-Didessa Dam&Irr Project, Didessa Pumping Project, Negeso Dam&Irr Project; Dabana Dam&Irrigation Project, Angar-Nekemte Dam&Irrigation Project,
- Finchaa Subbasin: Neshe Cane Agriculture Expansion Project: studies and tenderdocs completed for Finchaa Sugar Factory;
- North West basins: Dinder&Rahad&Galegu Subbasin: no studies ongoing or planned, all projects are dam dependent;
- Tekeze Basin: Humera, Angereb and Metema Irrigation Projects: some studies ongoing, all projects are dam dependent;
- Baro-Akobo Basin: Baro and Gilo Irrigation Projects, both projects are dam dependent.
- Additional project sites:
    - Ethiopia: Didessa State Farm and Dinger Bereha, both on Didessa River, just west of Arjo Didessa. Dinger Bereha covers part of the Dabana Project.
    - Sudan: Wad Miskeen, south of the southern tip of Rahad I Scheme. This site is considered to be part of Rahad I Scheme.

The project descriptions are presented in Annex A of this Main Report.

Map 01: Location of studied projects

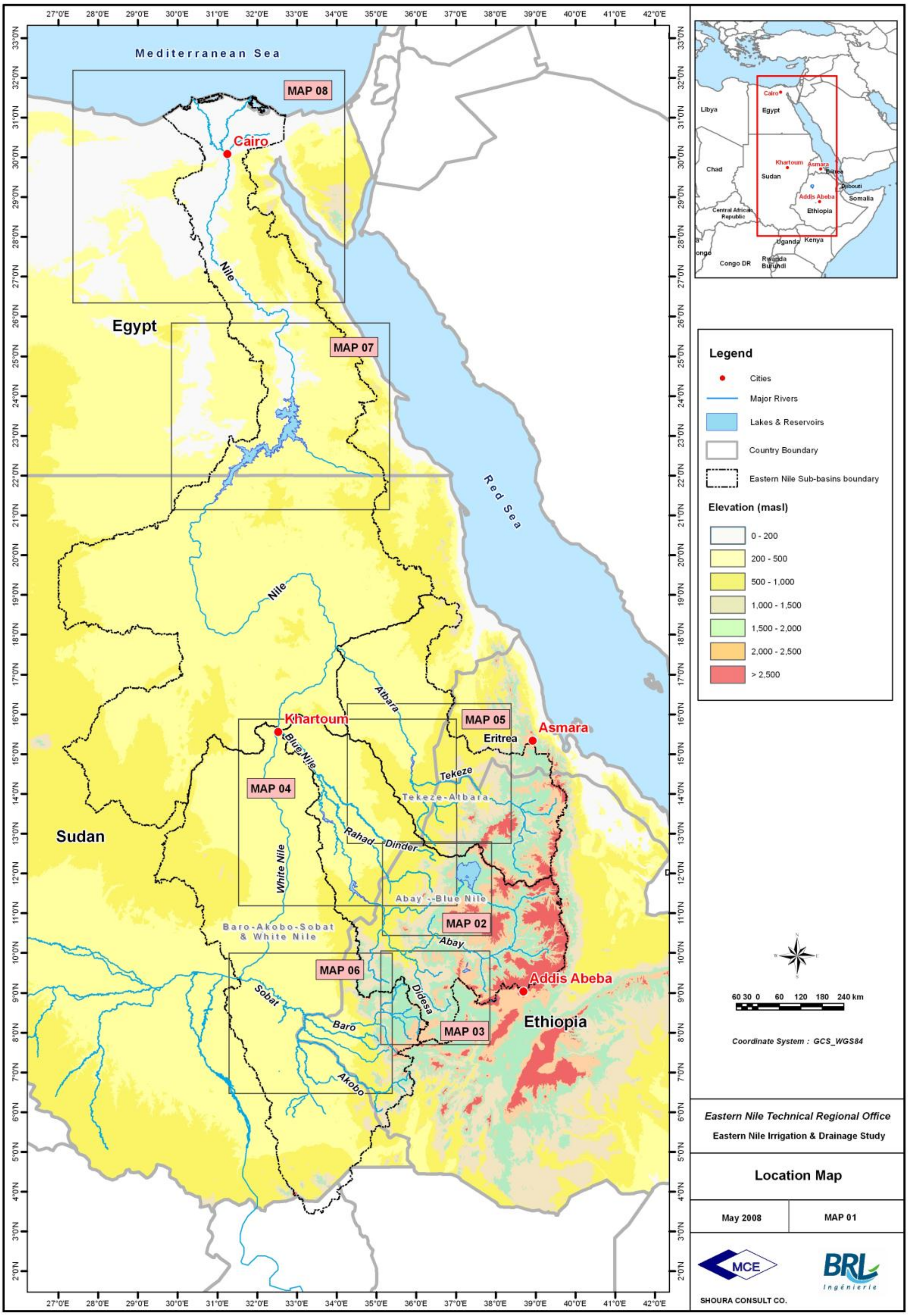

Table 2.1: Projects for which descriptions are presented

Code	Title	Irrigated area (ha)	Revised potential area (net ha)	Status of study
	Sudan Projects			
SU-1	Upper Atbara Development Project (Hydropower/Irrigation)	117,600	117,600	FS/DIU
SU-2	Great Kenana Irrigation Project	420,000	420,000	FS/DIU
SU-3	El Rahad Phase II Project	210,000	210,000	FS/DIU
Addition	Wad Miskeen	-	10,000	-
	Total Sudan Projects	***747,600***	***757,800***	
	Ethiopia Projects			
ET-IR1	Tana-Beles Irrigation Project	190,000		
	- Upper Beles	15,000-35,000	53,720	FS/WB
	- Lake Tana shores	40,000		
	Megech Pumping	15,000	24,510	FS/WB
	Megech Gravity		7,311	FS/WB
	Ribb [1], 4 sub-projects		19,927	FS/WB
	Gumara [1], 6 sub-projects		13,976	FS/GoE
	Gilgel Abbay [1] , 8 sub-projects		13,556	-
	NE Tana, 4 sub-projects		5,475	-
	Delgi *(= North West Tana 1-4)*	7,000	2,550	-
	Kunzila (= *South West Tana 1-4)*	5,000	1,960	-
	Zege (= *South West Tana 5)*	8,000	6,500	-
	East Tana [2]	5,000	-	-
	- Upper Dinder [1]	10,000	8,500	-
	- Lower Beles	90,000	85,000	-
	- Dinder (*Lower Dinder)* [1]		49,555	-
	- Rahad [1]		45,100	-
	- Galegu [1]		9,900	-
ET-IR2	Humera Irrigation Project	42,900	42,965	FS/GoE
ET-IR3	Didessa Irrigation Project (Hydropower/Irrigation)	53,483		
	- Arjo Didessa River [1]	14,280	13,665	FS/GoE
	- Negeso River [1]	22,815	22,815	FS/WB
	- Dabana River [1]	16,388	16,388	
	- DID1 (*Didessa Pumping Project)* [1]		4,803	
addition	Dinger Bereha gravity/pump scheme		8,100	
addition	Didessa State Farm		10,000	
ET-IR4	Angar-Nekemte Irrigation Project (s-scale Hydropower/Irrigation)	25,670	25,670	
	- Anger [1]		14,450	FS/WB
	- Nekemte [1]		11,220	
ET-IR5	Metema Irrigation Project (s-scale Hydropower/Irrigation) [1]	13,600	11,561	-
Addition	Angereb Irrigation Project [1]	--	16,535	-
ET-IR6	Neshe Irrigation Project (m-scale Hydropower/Irrigation)	11,153	4,670	DD/FSC
ET-IR7	Baro Irrigation Project [1]	50,000	50,900	-
ET-IR8	Gilo Irrigation Project [1]	46,900	46,900	-
	Sub-total Ethiopia		***648,182***	

[1] dam dependent. [2] not existing. FS/WB = included in ongoing WB financed 80,000 ha FS&DD study. GoE = undertaken by Governmentof Ethiopia. DIU = undertaken by Dams Implementation Unit. DD = detailed design.

2.2 WATER REQUIREMENTS

The calculation of the project water requirements for the Ethiopian projects is presented in Appendix 4. The information is based on the calculations, carried out during preparation of the Abbay Basin Master Plan (1994-1997). For the Sudan projects these types of calculations were not available and therefore, the water requirements presented in the specific project reports have been included in the project descriptions in Annex A. These figures have been used to determine the overall water requirements for Sudan.

3. COST CALCULATIONS

3.1 INVESTMENT COSTS

3.1.1 UNIT RATES

The unit costs adopted are based on rates that have been used in similar projects. Rates, adopted in contracts with Chinese operators are not considered representative and have therefore not been included in the assessment. The unit rates are shown in the tables below. They do not include costs for physical and price contingencies and engineering services. These rates have been used in detailed BoQ tables for typical structure, such as main conveyance canals, secondary systems, and major structures like pumping station, diversion weirs and intakes.

Table 3.1: Adopted unit construction rates, Ethiopia (March 2008)

Description	Unit	Rate (Birr)
GENERAL		
Clearing and stripping for canals, structures	ha	10 000
Access road, 3.5 m wide, gravel, with 1 m wide shoulders	km	180 000
Service road, 3,0 m wide, 0.20 m thick gravel layer	km	70 000
Regional road, 6 m wide, 150 mm gravel, incl. culverts	km	350 000
EARTHWORKS		
Excavation, open cut in rock	m3	185
Excavation in rock for cut-off trench	m3	185
Excavation, earth, canals and drains, by equipment	m3	30
Excavation, earth, structures, by equipment	m3	30
Excavation, earth, small drains, by hand labour	m3	20
Compaction, into canal embankment, no haul	m3	30
Compaction, into embankment, haul at 10 km	m3	50
Install of pipe, 1-2.5 deep, diam 0.35m (excl pipecost)	m	75
STRUCTURES		
Concrete in structures, incl formwork	m3	2 700
Concrete in canal lining, 80-120 mm thickness	m2	200
Reinforcing steel (80-100 kg/m3 concrete)	kg	17
Formwork	m2	120
Stone pitching, 0.20 m thick	m2	90
Masonry in structures, basa;tic stone, 0.50 m thick	m3	600
Riprap	m3	130
Quarry run rockfill	m3	50
Steelwork for gates and gateframes	kg	20
Filter gravel/sand	m3	160
Sheetpiling, steel	m2	10 000
MISCELLANEOUS		
Transmission line, 15 kV, wooden poles	km	300 000
Transmission line, 66 kV, steel pylons	km	400 000
Transformer, 50 kVA	unit	60 000
Transformer, 100 kVA	unit	100 000
Transformer, 200 kVA on pole	unit	95 000
Transformer, 250 kVA (in cabin)	unit	135 000
Office&staff housing facilities	ha	3 000
Electricity rate off-peak 380 V	kWh	0,54
Electricity rate peak (6-8 pm) 380 V	kWh	0,74
Pump stations, excl civil works, per installed kW	kW	16 000
Cement	t	15 000
MS Reinf. bar	t	20 000
Aggregate	m3	400
Sand	m3	150
Timber	m3	4 000

Table 3.2: Adopted unit construction rates, Sudan (May 2008)

Description	Unit	Rate (USD)
GENERAL		
Clearing and stripping for canals, structures	ha	3 000
Access road, 3.5 m wide, gravel	km	50 000
Service road, 3,0 m wide, 0.20 m thick gravel layer	km	40 000
Regional road, 6 m wide, 150 mm gravel, incl. culverts	km	55 000
EARTHWORKS		
Excavation, open cut in rock	m3	70
Excavation in rock for cut-off trench	m3	50
Excavation, earth, canals and drains, by equipment	m3	6
Excavation, earth, structures, by equipment	m3	10
Excavation, earth, small drains, by hand labour	m3	8
Compaction, into canal embankment, no haul	m3	3
Compaction, into embankment, haul at 10 km	m3	6
Install of pipe, 1-2.5 deep, diam 0.35m (excl pipecost)	m	100
STRUCTURES		
Concrete in structures	m3	300
Concrete in canal lining, 80-120 mm thickness	m2	30
Reinforcing steel (80-100 kg/m3 concrete)	kg	2
Formwork, flat	m2	100
Stone pitching, 0.20 m thick	m2	150
Masonry in structures, basa;tic stone, 0.50 m thick	m3	50
Riprap	m3	
Quarry run rockfill	m3	
Steelwork for gates and gateframes	kg	
Filtter gravel/sand	m3	
Formwork	m2	120
Sheetpiling, steel	m2	
MISCELLANEOUS		
Transmission line, 15 kV	km	31 500
Transmission line, 66 kV	km	21 000
Transformer, 50 kVA	unit	
Transformer, 100 kVA 33/415	unit	8 250
Transformer, 100 kVA 11/415	unit	8 250
Transformer, 200 kVA on pole 33/415	unit	10 000
Transformer, 200 kVA on pole 11/415	unit	9 500
Transformer, 250 kVA (in cabin) 33/415	unit	13 750
Transformer, 250 kVA (in cabin) 11/415	unit	13 500
Transformer, 500 kVA (in cabin) 33/415	unit	20 000
Transformer, 500 kVA (in cabin) 11/415	unit	17 500
Pump unit, electric, Q=1 m3/s, H=20 m (350 HP)	unit	
Pump unit, electric, Q=2 m3/s, H=10 m (350 HP)	unit	
Pump unit, electric, Q=2 m3/s, H= 20 m (700 HP)	unit	
Cement	t	600
MS Reinf. bar	t	2 000
Aggregate	m3	40
Sand	m3	30
Timber	m3	

3.1.2 INFRASTRUCTURE

Analysis of 1997/1998 costs and the unit rates of 1998 and 2008 in Ethiopia has shown that in general the costs have increased by 100% in terms of Birr. The cost calculation are based on the following assumptions :

- Pumping stations, pumps and ancillary equipment : Unit rates for various pump units with different heads and capacities, as well as for transformers and ancillary electric equipment have been obtained from projects in Africa and Europe. Using this information cost functions were prepared with the following variables:
  - dynamic head in m
  - capacity in m^3/s
  - number of pump units

- number and capacity of transformers

The resulting cost functions were developed as follows:

- $IC = IC_p + IC_{hm} + IC_e$, where
  - IC = overall cost without civil engineering in USD
  - IC_p = costs for pumping equipment, with $IC_p = P_i$ x 1,000 USD and Pi = installed power, including standby;
  - IC_{hm} = costs for hydro-mechanical equipment = 0,8 x IC_p ;
  - IC_e = costs for electrical equipment = 0,8 x IC_p
- Costs of civil engineering pumping stations: according to nomograph
- Rising mains: made of steel, costs ranging from 1,700 Birr/m for φ = 400 mm and 5,100 USD/m for φ = 1,000 mm.

- Weirs : costs functions have been developed using the following variables:
  - depth of river (3-7 m)
  - height of weir crest above riverbed level (1-6 m)
  - length or weir which equals the width of the riverbed
  - foundation conditions: pervious erodable soils and impervious rock
- Intakes : costs for intakes have been calculated using the following parameters :
  - number of barrels (1-5), as function of the diverted flow, and
  - the depth of river
- Pumping stations, pumps and ancillary equipment : Unit rates for various pump units with different heads and capacities, as well as for transformers and ancillary electric equipment have been obtained from projects in Africa and Europe. Using this information cost functions were prepared with the following variables:
  - dynamic head in m
  - capacity in m^3/s
  - number of pump units
  - number and capacity of transformers
- Pumping stations, civil works : cost nomographs have been prepared according to the number of pumps or bays, determining the length of the station. The bills of quantities include items such as excavation, backfill, concrete, reinforcement, formwork, masonry walls, steel for doors, windows and railings, roofing, structural steel for gantry, and miscellaneous items (20%).
- Main canals: Costs were calculated on meter and m^3 basis, with the following variables:
  - bottom width of canal
  - water depth
  - bank slope
  - cross slope
  - concrete lining for permeable soils or riprap for impermeable soils
  - earth or rock excavation

The costs include construction of a gravelled inspection/project road on the lower side of the canal and drainage facilities on the upper side of the canal.

- excavation in canal 0.85 m^3/m
- fill on field side 0.85 m^3/m
- lining d= 80-120 mm, 0.29 m^3/m on average, 2,9 m width
- roadfill and road dike 1.22 m^3/m

3.2 RECURRENT COSTS

3.2.1 POWER AND ENERGY REQUIREMENTS OF PUMPING STATIONS

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

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

The energy requirements per hectare are shown in tables 4.3 and 4.4

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

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

- Maintenance of civil works (weirs, buildings etc) : 0,5% of investment costs (IC)
- maintenance of canals: 0,5% of IC
- maintenance of structures: 1% of IC
- maintenance of mechanical and electrical equipment: 2% of overall investment costs for electrical and mechanical equipment.
- electricity costs: depending on required lift, water requirements and kWh price, (see unit rates Ethiopia and Sudan).

- Staff costs : have not been included.

Other assumptions :

- *development of cost-estimates*: the itemisation has been carried out in relation to the detail appropriate for reconnaissance level. Estimated costs are based on unit rates for different quantities, with aggregate rates for reconnaissance studies;
- *contingencies*: contingencies have been included to cover unforeseen price and physical increases. For the ENIDS estimates physical and price contingencies amount to 20% and 5% of the base costs respectively;
- *design, engineering, administration and project management*: these items require an additional 5% of the sum of base costs and contingencies and cover items such as prefeasibility, feasibility and detailed design by consultants, aerial photography and mapping, and construction supervision by consultants; project management by the Client is not included.

3.3 OVERALL COSTS

The investment and recurrent costs for all projects are summarised in tables 4.3 and 4.4 below. They are based on the detailed project cost sheets, presented in Appendix 2.

Table 3.3: Summary of investment and recurrent costs of all projects, Ethiopia

Project name	Project code	Net irrigable area	Pumped Water	Gross water requirement irrigation	Total investment costs I&D infrastructure	Total recurrent costs I&D infrastructure	Electricity charges pumping stations
		ha	MCM/year	MCM/year	birr/ha	birr/ha/year	birr/ha/year
TEKEZE PROJECTS							
1 ANGEREB	TEK1	16 535	223	223	108 124	818	1 826
2 METEMA	TEK2	11 561	156	156	84 914	654	1 504
3 HUMERA	TEK3	42 965	921	921	120 818	1 047	2 019
NW BASINS							
4 RAHAD	GAL1	45 100		501	81 129	281	-
5 LOWER DINDER	DIN2	50 000	197	560	83 123	351	297
6 GALEGU	GAL1	9 900		108	63 442	233	-
LAKE TANA BASIN							
7 AMBO PLAIN	GIL1	561		4	50 080	168	
8 AMIR PLAIN	GIL2	2 950		22	47 810	181	
9 GUG&INSEWI	GIL3	2 066	16	16	58 744	329	239
10 KOGERA/DEBL PLAIN	GIL4	2 338	18	18	42 319	232	239
11 CHIMBA	GIL5	1 921	15	15	50 346	278	239
12 DIYALEG	GIL6	1 468	11	11	57 095	354	239
13 LIGOME RISTE	GIL7	765	6	6	66 961	425	239
14 DIMBK PLAIN	GIL8	1 487		11	37 746	137	
15 RIBB RIGHT BANK 1800	RIB1	6 505		64	39 374	153	
16 RIBB RIGHT BANK 1820	RIB2	2 601	26	26	58 964	425	447
17 RIBB RIGHT BANK 1800	RIB3	7 956		79	37 213	141	
18 RIBB LEFT BANK 1820	RIB4	2 865	28	28	62 525	449	550
19 MITRHA	NET1	1 632	14	14	63 416	445	445
19 GUBAY MARIAM	NET2	1 768	15	15	81 261	676	525
20 KIRNYA	NET3	842	7	7	77 457	620	626
21 AGID/KAB	NET4	1 233	10	10	77 972	659	626
22 SERABA	MEG1	4 854	39	39	54 746	383	393
23 ROBIT	MEG2	5 495	44	44	43 779	280	267
24 GURAMBA	MEG3	5 644	45	45	52 657	353	393
25 JARJER	MEG4	8 517	68	68	56 978	434	644
26 KOLA DIBA	MEG5	2 576		21	35 183	186	
27 JEWANA	MEG6	4 735		38	34 488	178	
28 BEBEHA ABO	NWT1	2 388	19	19	53 668	315	562
29 GAWRNA	NWT2	1 076	9	9	69 593	512	581
30 FENTAY	NWT3	706	6	6	72 704	513	581
31 DELGI	NWT4	2 550	20	20	52 414	344	738
32 GURAMBA	GUM1	1 742		14	35 086	143	
33 MENEGUZER	GUM2	1 380	11	11	80 885	621	377
34 ABAKIRO	GUM3	424	3	3	65 363	415	173
35 BEBEKS	GUM4	2 376		19	40 542	206	
36 JIGNA	GUM5	4 199		34	34 362	128	
37 HOD GEBEYA	GUM6	3 855		31	34 511	149	
38 ISTUMIT	SWT1	1 041	8	8	67 535	501	283
39 ASINWARA	SWT2	1 876	15	15	80 288	625	612
40 KUNZILA	SWT3	1 960	16	16	63 221	466	712
41 LIGOME GABRIEL	SWT4	255	2	2	82 279	545	345
42 ZEGE	SWT5	6 500	52	52	46 906	288	400
DIDESSA SUB BASIN							
43 ARJO DIDESSA	ARJ1	13 665		191	49 820	161	
44 DIDESSA PUMPING	DID 1	4 803	48	48	83 604	445	726
45 DABANA	DAB1	16 388		100	59 102	188	
46 DINGER BEREHA GRAVITY&PU	DID3	8 100	24	81	73 391	285	206
46a DIDESSA STATE FARM	DID4	10 000	30	100	104 614	829	2 002
47 NEGESO	NEG1	22 815	36	121	60 722	158	
ANGER-NEKEMPTE SUB BASIN							
48 ANGAR	ANG1	14 450	92	92	46 953	244	112
49 NEKEMTE	ANG2	11 220	72	72	68 628	512	754
FINCHAA SUB BASIN							
50 NESHE SUGARCANE EXT	NES1	4 670		37	81 710	817	
BARO-AKOBO SUB BASIN							
51 BARO RIGHT BANK	BAK1	50 900	108	555	59 035	155	17
52 GILO RIGHT BANK	BAK2	46 900	108	511	60 799	159	18
BELES SUB BASIN							
53 UPPER BELES	BEL1	53 720		532	65 247	206	
54 LOWER BELES	BEL2	85 000		850	45 461	125	
55 UPPER DINDER	UDI1	8 500		72	31 324	112	

Table 3.4: Summary of investment and recurrent costs of all projects, Sudan

	Project name	Project code	Net irrigable area	Pumped Water	Gross water requirement irrigation	total investment costs I&D infrastructure	total recurrent cost I&D infrastructure	electricity charges pumping stations
			ha	MCM/year	MCM/year	USD/ha	USD/ha/year	USD/ha/year
1	ATBARA	ATB	99.000		1.900	7.183	24	
2	KENANA	KEN	420.000		6.300	6.589	22	
3	RAHAD 2	RAH2	210.000		3.150	7.246	25	
4	WAD MISKEEN	WAD	7.500		113	6.246	28	

4. COST AND BENEFIT ANALYSIS

4.1 THE CONTEXT OF ANALYSIS

To facilitate the selection of potential development scenario's the main target is to construct a framework relevant to represent the diversity of each project, in each country, without excluding any project. The main difficulty originates from the different feasibility level of available data with regard to present context specifically relating to market organisation, price distortion, and technical enhancement. Since the Masterplan studies of ten years ago many parameters have changed and updating costs and benefits to the same level of detail is a big challenge. Much attention has been given to all components of the analysis to understand the project context and to formulate and summarise the main elements useful for the comparison. Furthermore, the present situation has to be compared to the forecasted one in order to determine the real project increment.

In order to provide the four main criteria to compare projects, such as TIR, VAN, discounted ratio B/C, and equilibrium price of cubic meter water used for irrigation, two stages are identified:

1. the construction of a template to describe the farm activity,
2. the cost-benefit analysis.

These stages are elaborated in the following sections. Appendix 3 presents supporting information.

4.2 THE DESCRIPTION OF FARM ACTIVITY

4.2.1 FARM MODELS

To simplify calculations and procedures two types of farm organisation have been adopted: the commercial structure, and the family farm. Projects combining the two systems are not frequent, but when they exist we have used information from MoWR (Ethiopia) and MWR (Sudan) based on regional development programs to introduce a fair number of small holders and their family to keep good correspondence with the social impacts foreseen.

A **commercial farm** is identified by its big size, and by the permanent control by the selling organization. The commercial farm is able to produce and sell industrial crops well sized for the market demand and for industry capacity. Overall production will be oriented towards a big markets, or agro business factories, either regional, national or international. The group of commercial farm can includes estate or private farms. The management is not a decisive option for our results, and these two ways have a well known ability to develop high absorption commercial networks.

The **family farm** controls a production surface well suited for the family capacity of work (men and oxen), without mechanised means. The typical farm area of 1-2 hectares is common in Ethiopia, with an average of 1,5 ha that remains a realistic figure for many irrigated perimeters. In Sudan this average is higher, and more or less stabilized around 4.2 ha (or 10 feddans). The production is principally sold at local or regional markets, and part of the production is kept for direct famil8y consumption, with an important contribution to improve family livelihood.

The same farm gate price has been adopted in both systems, assuming high demands of foods on non-saturated markets, independent of strong development of the new operational irrigation projects.

The difference between the two systems appears at the level of cropping patterns and in the final yield levels.

4.2.2 CROPPING PATTERN

Generally, cropping patterns are given in former surveys and studies, identifying rainy and dry seasons, with a set of crops adapted to climate and cropping calendar. We used these data to compose project cropping patterns, and to describe the existing cropping patterns, to be used in the calculations of the before-project case. But in some cases, in order to take into account the realistic problem of water availability, or distance to agro business industry or again too weak gross margin, the set of crops has been optimised, keeping more traditional crops. Often the trend of feasibility survey is to introduce new crops with high added value. The capacity of small holder requires adjustment of ambitious planning and leads to keeping cropping patterns commonly adopted by farmers,. For example following the ministerial information we don't introduce sugar cane in the cropping pattern for Upper Atbara project in Sudan, because the industrial complexes are too far away from the project area. We avoid introducing rice in Lake Tana sub basin, because of the drainage issues, and also because of difficulties with levelling by for small farmers. We discard fodder in area where Tsetse fly may cause extensive cattle diseases. To summarise, in each case we try to respect the needs of population and the farmer's knowhow, as regarding the former investigations to promote modern agriculture, that will improve the supply of food.

In Sudan it will be useful to identify two cropping pattern for the big farms, in order to introduce industrial crops in the first model, and more traditional crops in the second. The example given below shows a cropping pattern developed with many crops. This scheme is in fact current in the feasibility surveys in order to ensure sufficient farm revenue to the family. Diversification stays always a target for producers.

Table 4.1: Cropping pattern proposed for Arjo Didessa project

ARJO - DIDESSA				
Net Cultivated area	14 300 ha	Without project	With project Commercial farm	With project Family farm
		%	%	%
Rainy season	Barley *	13%		
	Maize *	24%	40%	30%
	Millet *	9%		
	Onion *	2%	15%	10%
	Potato *	2%		5%
	Sorghum *	15%		5%
	Sunflower *		15%	
	Teff *	30%	30%	35%
	Wheat *	5%		15%
Dry season	Groudnut		15%	
	Maize		15%	15%
	Onion		3%	7%
	Potato			5%
	Sesame		7%	8%
	Wheat		10%	
	Total	100%	150%	135%

Cropping intensities can reach values of 150% for the biggest farm where the mechanisation allows for increased rotation. In this case cereals are dominant, following demand in regional and national markets.

The program for small holders is intensive, offering a wide range of food crops and cash crops[1].

Teff is kept due to the scarcity of this product in the country, and its important role in the usual feeding pattern. Recently the price of this traditional crop has increased very strongly, due to a big shortfall in production, and following the general trend where the cereal prices continue to increase drastically since January 2007[2].

4.2.3 YIELDS

This important component of the analysis mobilizes has required large efforts in order to respect the main constraints of the area, combining soil capacity, availability of water, ability of farmers to produce with a regular effort, and market organisation. These are the main elements influencing yields. In each case the average figures have been preferred over the higher values. Exceptional yield levels have been avoided. A 5 year schedule has been assumed to reach the maximum level of revenue. This period has been reduced to 3 years for the commercial farms that benefit of modern technology and more important financial means.

Table 4.2 : Example of maximum yields

TEKEZE				
Yields		Without project Q / ha	With project Commercial farm Q / ha	With project Family farm Q / ha
Rainy season	Groundnut rainf.	9.0	40.0	35.0
	Haricot bean rainf.	4.0		
	Sesame rainf.	3.5	15.0	13.0
	Sorghum rainf.	10.0	15.0	14.0
	Teff rainf.	6.0		
	Vegetables rainf.	50.0	250.0	200.0
	Sudan grass			
Dry season	Cotton		30.0	
	Haricot bean			15.0
	Pulses		15.0	
	Sesame			
	Sorghum		18.0	16.0
	Vegetables		300.0	250.0

The yield increase in the with-project situation seems high, especially with regard to present the situation. In fact the figures reflect a reasonable situation with regular irrigation to correct drought effects. Nevertheless this kind of progress supposes an important preparation of the farmers and a set of accompanying measures, supported by agricultural extension services.

In Ethiopia yields are given en Q/ha and for Sudan they are shown in t/ha applying a 0.42 conversion rate from feddan to hectare.

[1] - Towards a strategy for support to make agricultural markets work better for the poor : the grain marketing system in Ethiopia. March 2003 – Oxford Policy Management to assist EC delegation in Ethiopia – DFID funded.

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[2] - Market Analysis – March 2008 – USAID Ethiopia from Bellmon analysis

4.2.4 FARM GATE PRICES

It was difficult to collect accurate information on the price of goods and merchant crops. The data are widely spread out in many surveys, official documents, localized reflexions, and above all, most are given for the past at distant years (10 years ago), at different periods during a year, at different places, and at different levels of transaction (wholesale, retail, local market place, etc.)

Efforts have been focused on three main elements: the localisation of the transaction for the producer, the evolution of the prices from 1998 and the seasonality of crop prices.

In the scope of our analysis the first and direct beneficiary of the irrigation project is the farmer. Investments for irrigation systems are principally made to develop the agricultural production, with the target to compare the costs and the revenues made at farm level. Obviously, the farm gate price remains the best parameter to calculate the direct project revenue; it is generally well identified in the raw material of the surveys that have been used. Transportation cost to reach market places are not included in the cost of the irrigation project. The use a market price to evaluate the benefit of irrigation project needs at least, identification and financial evaluation of transports means, storage commodities, broker benefit, insurance costs. These components are widely unavailable at the scale of our projects. In our case this kind of evaluation has been discarded.

In the case of industrial transformation of products, such as cotton or sugar cane the final added value of fibres, oil, or sugar must take into account the investments to reach this final stage. This kind of costs is not included in the project investment.

From 1998, a lot of evolution has been noticed in the value of crop production. A farm gate price correction is obviously necessary to compare the projects.

In Ethiopia, data are given at different years: 1998 (Abbay River basin Master Plan, Tekeze Master Plan, or North East Lake Tana prefeasibility survey), June 2006 (Arjo Didesa irrigation Project and Irrigation and drainage projects in the Nile Basin of Ethiopia - Tahal survey), June 2007 (Market assessment study – MoWR). To update the value to the April 2008 level we have used the official information provided by the CSA (Central Statistical Agency of Ethiopia), such as:

- ✓ the former series of average retail prices of goods and services at national and regional level, from 1996 to 2000, trough statistical bulletins;
- ✓ The CPI (consumer price indices) at country and regional level from December 2000 to April 2008, through information bulletins, identifying food and non food product, and details for cereals, pulses, vegetables; and
- ✓ The country level general inflation rate from September 2008 to April 2008 (revised from January 2007 to November 2007), trough N°7 bulletin of 12 May 2008.

Table 4.3 : Inflation rates in Ethiopia

Source: CSA	Géneral Index	Food	Non Food
From 1998 to December 2000	0	0	0
From January 2001 to September 2006	62.9%	79.9%	40.4%
From September 2006 to December 2006	1.4%	0.9%	2.0%
From January 2007 to April 2008	36.6%	49.8%	19.2%
From 1998 to April 2008	100.9%	130.6%	61.6%

From 2007 the acceleration of the inflation is particularly strong in the food area. Before 2000 the inflation was very weak and not significant at the scale of this study (close to 0%). These different rates have been applied for each value that has been used. Each time the rate used appears in clear in each sheet of calculation. The sources of data allow us to identify the three main regions on concern by the analysis: Amhara, Benishangul-Gumuz, and Oromiya Regions. Thus, new values could be determined taking into account the location of each project.

In Ethiopia the surveys provided recent information, with data from March 2008. These were used directly without correction.

The last point of this subject underlines the attention paid to obtain correct inflation rates for vegetables (especially for tomato and potato) that are subjected to monthly variations in market prices due to harvest time and weak capacity of storage. The peaks (maximum and minimum) were discarded to calculate average values.

4.2.5 PRODUCTION COSTS

Production costs provide typically information that has been accepted with confidence. They are generally the result of a long and good enquiries conducted closely at producer levels. MoWR is the main provider for the analysis of the component of the recurrent costs at farm level, with detailed technical patterns, including inputs, man power, and external services. Moreover, the research institutes can indicate the main precaution to use average figures when large irrigated perimeters are involved. In Ethiopia and in Sudan land and production taxes are included in the calculation of production costs. Generally, the surveys indicate an evolution spread over 3 to 5 years, with an increase in the cost linked to yield evolution. We follow the indication given to compose the cost at final stage of evolution. All production costs are updated with April 2008 values.

4.2.6 NET MARGIN CALCULATION

Net margin calculation is the last component of the farm analysis, giving a financial result for technical component combination. The margin is calculated on hectare basis and for each crop and represents the difference between the gross earnings (yields multiplied by farm gate price) and the production costs. The different taxes are included in the calculation of production cost, so the result obtained can be considered as the net margin per hectare.

Table 4.4: Example of Net Margin calculation for year 5

	Crop	Farm gate price Price	Yield 5	Total production revenue	Total purchased inputs	Net margin
		ETB/Q	Q/ha	ETB/ha	ETB/ha	ETB/ha
rainfed season	Maize *	248	40	9 918	3 308	6 610
	Onion *	331	120	39 696	14 657	25 039
	Sorghum *	338	15	5 075	1 734	3 341
	Sunflower *	594	15	8 908	3 132	5 776
	Teff *	588	14	8 225	2 365	5 860
	Wheat *	308	25	7 690	4 074	3 616
dry season	Groudnut	566	40	22 624	4 232	18 392
	Maize	248	40	9 918	3 458	6 460
	Onion	331	150	49 620	20 138	29 482
	Sesame	913	10	9 134	1 959	7 175
	Wheat	308	45	13 842	5363.16	8 479

The net margin is a good indicator to identify the high value crops and to influence the choice of the cropping pattern. Specific attention has been given to check the coherence of the results inside each project.

This component will compose the base of the project benefit in the cost-benefit analysis. With this homogeneous base projects can be compared properly.

4.3 DEVELOPMENT OF A MODEL FOR EVALUATING OF COSTS AND BENEFITS OF IRRIGATION PROJECTS

4.3.1 GENERAL

When comparing the performances of several projects, the aim of the cost-benefit analysis is to assess the benefits that the investment brings to the irrigation infrastructure manager. The framework for the analysis is therefore financial since the transfer of money is analysed. This type of analysis is particularly appropriate for classifying a series of technical solutions since it is designed to compare:

- ✓ project costs: investment (hardware and software) and operating costs,
- ✓ with the benefits expressed in terms of farm profits.

In a cost-benefit analysis, a project becomes a series of expenditure and income values over a sequence of years. These values materialise in a positive or negative cash flow balance throughout the project. The analysis is done over a period of 30 years. By principle a discount rate is applied to enable comparison over the whole period. The value of the flows is thus weighted according to the years for which they are computed. All the projects are analysed using the same principle which makes it possible to compare the results obtained for the same time basis. It is important to remember that this updating method is totally independent from inflation or monetary erosion.

In this kind of analysis financial terms as amortization of capital or fees interests or pay off for a loan must not taken into consideration. To compare the projects it is not necessary to know how the financial resources are mobilised. The analysis is concentrated exclusively on the technical components, not on financial ones.

The purpose of the model is to be able to determine the financial cash-flow which is used to calculate project performances. The calculations will be presented as time vectors so that project income can be compared with project expenditure. The difference between the two gives the cash-flow.

4.3.2 MAIN COMPONENTS

Investments include construction works, specific surveys and items like physical and price contingencies. This sum is assumed to be spent during the fist year of the project, with the assumption of one year installation of equipments and water service delivery.

The **annual costs** are following the investments, but they are calculated for each year of the 30 years of analysis. Two components are distinguished: the recurrent cost including O&M cost and replacement, and the electricity charges for pumping stations.

The **benefit of the project** is calculated on hectare basis, using distribution of the crops according to cropping pattern. We obtain an average net benefit, with a progressive increase during the first four year of production.

The benefits are shared in two components to take into account the situation before the implementation of the project (present situation). The final benefit created by the project is the difference between the forecasted and the present one. It will be negative in the case of production of sugar cane during the first year of cultivation.

Table 4.5 : Example of Net Revenue for the first years of the project

ANGER				
Net Benefit	ETB/ha	Without project	Anger Commercial farm	Anger Family farm
			ETB/HA	ETB/HA
	PY0 Project Year 0: implementation of works			
	PY1	3 626	8 216	10 607
	PY2	3 626	10 173	11 488
	PY3	3 626	12 616	13 169
	PY4	3 626	13 905	14 656
	PY5	3 626	14 987	16 761
	PY6	3 626	14 987	16 761
	PY7	3 626	14 987	16 761

The calculation identifies the benefit of family farm and another one from big commercial farm. In the presented case the family farm has a cropping pattern with vegetables and onion which have a high value added. In this family farm if we reduce the superficies of the vegetables we obtain a value around 14 000 ETB /Ha, closer to the commercial farm benefit.

In Sudan a specific average was computerised to take into account different models of big farm in the same irrigation project.

The comparison between benefit and project cost are enlighten with **the cash flow**. The cash flow constitutes the main element of the result. It will support all relevant ratios that we want use for classification of projects.

4.3.3 RESULTS

The results of each model are concentrated on the cash-flow basis, which allows to calculate:

- ✓ The internal rate of return IRR. The higher it is, the better the financial performance of the project.
- ✓ The net present value (NPV) for a discount rate selected within a series of values that reflect the desired profitability level and risks of the project. In this case and regarding the different results a collective discount rate of 2% was assumed.
- ✓ The B/C ratio using the same discount rate.
- ✓ The average dynamic (real-time) cost per cubic metre or the equilibrium price of water for a period of 30 years.

Table 4.6 : Financial results of Ethiopian projects

Code	Title	Net irrigable area	total investment costs infrastructure	IRR	NPV	B/C	Equilibrium price for m³
	ENIDS			**Summary of Financial Results**			
				Project Results			**Value: April-08**
					Discount rate: 2%	Discount rate: 2%	
ETHIOPIA Projects		ha	birr/ha	%	Million Birr		Birr
ET-IR1	**Tana-Beles Irrigation Project**						
	Beles Sub Basin	**147 220**	51 865	17.9%	44 017	4.84	0.25
	- Upper Beles						
	- Upper Dinder						
	- Lower Beles						
	Lake Tana Shores						
	Megech						
	Megech (Pumping system)	24 510	52 582	7.4%	2 147	1.8	0.40
	Megech (Gravity system)	7 311	34 733	13.4%	907	3.2	0.19
	Ribb, 4 sub-projects						
	Ribb (Pumping system)	5 466	74 916	4.8%	393	1.4	0.40
	Ribb (Gravity system)	9 370	38 185	12.3%	1 759	3.0	0.19
	Gumara, 6 sub-projects						
	Gumara (Pumping system)	1 380	141 223	-1%	-39	0.71	0.98
	Gumara (Gravity system)	12 596	20 680	21.6%	1 713	5.48	0.13
	Gilgel Abbay, 8 sub-projects						
	Gilgel (Pumping system)	8 558	52 823	8.0%	817	1.92	0.38
	Gilgel (Gravity system)	4 998	45 070	10.4%	570	2.55	0.29
	NE Tana, 4 sub-projects	5 475	74 616	3.9%	309	1.2	0.53
	Delgi (=North West Tana 1-4)	2 550	55 414	6.9%	205	1.6	0.43
	Kunzila (=South West Tana 1-4)	1 960	63 221	5.1%	131	1.4	0.50
	Zege (=South West Tana 5)	6 500	49 906	8.8%	632	2.0	0.35
	NW Basin						
	- Dinder (Lower Dinder) (Pumping System)	49 555	83 123	20.2%	15 687	4.26	0.39
	- Rahad & Galegu (Gravity system)	55 000	77 945	21.9%	18 132	5.04	0.34
Tekeze Projects (Pumping system)		71 061	112 023	12.5%	15 686	1.98	0.43
ET-IR2	Humera Irrigation project						
ET-IR5	Metema Irrig. Project (S-Scale hydropower/irrigation)						
	Angereb Irrigation Project						
ET-IR3	Didessa Irrigation Project (Hydropower/Irrigation)						
	Didessa Pumping Project	**22 903**	89 048	9.0%	13 551	2.0	0
	- DID1						
	- Dinger Bereha State Farm	8 100	73 390	13.3%	2 034	3.1	0.38
	- DIDESSA State Farm	10 000	104 610	6.5%	1 475	1.5	0.75
	Didessa Gravity system	**52 868**	57 402	16.2%	13 551	4.0	0.35
	- Arjo Didessa River						
	- Negesso River						
	- Dabana River						
ET-IR4	**Angar-Nekemte Irrigation Project (Hydropower/Irrigation)**	25 670	56 427	15.3%	6 062	3.27	0.51
ET-IR6	Neshe Irrigation Project (m-scale hydropower/irrigation)	4 670					
	Baro-Akobo Sub Basin	**97 800**	31 643	49.1%	37 059	12.67	0.14
ET-IR7	Baro Irrigation Project	50 900					
ET-IR8	Gilo Irrigation Project	46 900					

Table 4.7: Financial results of projects in Sudan, improved rainfed

Project name	Code	Net irrigable area	Gross water requirement	total investment costs	total recurrent cost	IRR	NPV	B/C	Equilibrium price per m3
							Discount rate: 2%	Discount rate: 2%	
		ha	MCM/year	SDG/ha	SDG/ha/y	%	million SDG		SDG/m3
ATBARA	ATB	99,000	1,900	14,366	48	1.5	360	1.0	0.04
KENANA	KEN	420,000	3,990	13,178	44	2.1	2,074	1.0	0.07
RAHAD2	RAH	210,000	2,000	14,492	50	1.4	725	0.9	0.07
WAD MISKEEN	WAD	7,500	57	12,500	56	2.4	40	1.1	0.08

5. MULTI CRITERIA ANALYSIS

5.1 DESCRIPTION OF SELECTED CRITERIA

In the present era of market-based economy and cost recovery, financial criteria such as the financial internal rate of return are given the highest importance by international development banks. In the previous sections we give the results of calculations of financial indicators based on direct costs and benefits of proposed irrigation scenarios. We think important adding another set of criteria related to socio-economic costs and benefits generally associated with the nature and objectives of irrigation development projects to avoid a too narrow approach focussing only on financial aspects.

5.1.1 Financial criteria

Financial Internal Rate of Return

International development banks assess the merits of an investment by measuring the Financial Internal Rate of Return (EIRR). For irrigation projects, the FIRR equals the parameter 'r' in the following equation:

$$(1+r)^m K = \Sigma^{30}{}_{j=1}(R - C) / (1 + r)^j$$

where K = cost/ha of project, R = return/ha due to irrigation, C = O&M costs/ha, n = lifetime of project assumed in our analysis to be 30 years and m = gestation period of investment. A rate of 10% is the threshold value widely adopted among international donor agencies when evaluating the outcome of an investment project, below which the investment is considered, if *ex-ante*, not worth implementing and if *ex-post*, a failure.

Because of the importance given to the FIRR by international agencies, project planners in many countries often make over optimistic assumptions on costs and benefits of projects; we try to avoid this bias in our analysis. The FIRR represents a banker's perspective for considering investment but it is widely recognized that selection of investment options for economic development of a country should involve a negotiation process involving many stakeholders that may not have the same view as bankers. Furthermore the FIRR is calculated from the direct costs and benefits of irrigation development. It does not take into account the flow of opportunities that goes along with irrigation development; the so called "multiplier effect" or the backward and forward linkages. The FIIR also does not incorporate the negative and positive impacts of irrigation development on environment which are very difficult to assess in monetary terms. Based on these comments, we recommend using the FIRR as an important criteria but not the only one as often do international development banks.

Unit costs of infrastructure (UCI)

The unit cost is defined as the total cost of a project divided by the project size measured as the irrigated area which is benefited by an irrigation project. The total cost of an irrigation project is the sum of two distinguishable costs:

- ✓ The infrastructure cost: the cost of physical irrigation infrastructure such as dams, diversion weirs, canals, etc; and
- ✓ The software cost which includes engineering management, technical assistance, agriculture extension services, institution building, training of irrigation agency staff and beneficiaries and so on.

For our analysis, only infrastructure costs were made available. We believe unit infrastructure cost is a useful criterion for comparing projects because of (1) government budget constraints; (2) many previous studies have shown that expensive projects have greater risk of failure and (3) operation and maintenance (O&M) costs are proportional to infrastructure investment costs, thus cost recovery of O&M is easier in projects with lower infrastructure costs.

Equilibrium price of metre cube of water (EPW)

The equilibrium price of water is the total cost of water applied for irrigation during the lifetime of the project, assumed here to be 30 years. It is given by the following equation.

$$\mathbf{EPW = \sum_{j=1}^{30} (I + C)_j \,/\, (m^3 \text{ water used for irrigation})_j}$$

where "I" = infrastructure investment costs and "C"= operation and maintenance costs.

This criterion gives a monetary value of water used for irrigation. Projects having a low EPW are preferable because investments costs of these projects are better valued by water.

Gross margin per ha in years with maximum yield (GM).

The gross margin per ha (GM) is the value of production at farm gate/ha minus direct production costs /Ha. Direct production costs are the costs of agricultural inputs (seeds, fertilizers and pesticides). By cruising years we mean the period beyond the time needed by farmers to fully adopt improved technology packages. Alike the FIRR represents the perspective of bankers; the GM is the perspective of farmers, assuming farmers would select irrigation projects that generate more money for their labour. The GM can also be taken as a criterion of impact of irrigation development on poverty reduction as well as impact on macro economy, i.e. contribution of the project to GDP.

5.1.2 Socio-economic criteria

Level of existing economic infrastructures (LEI)

It is now widely recognized that irrigation performs better and is more effective in addressing poverty if complementary investments such as roads, storage facilities and agro-industries are made or already exist. Irrigation development zones present significant contrasts in terms of economic infrastructures. Additional investment costs needed where economic infrastructures are poorly developed have not been measured. However, based on existing economic infrastructure in each irrigation development zones, need for other economic investments can be qualitatively assessed.

Level of existing Social infrastructures (LSI)

In irrigation development zones having a low population density, irrigation investments must be accompanied by other investments for resettlement of population, i.e. housing, schools, health centres and so on. These additional costs have not been measures but can be qualitatively assessed for each irrigation development zones.

Population density (Pop)

In highly populated areas, irrigation development is one mean to control environment degradation through intensification of agriculture instead of expansion of agriculture on marginal lands. Furthermore one can assume that irrigation projects have a greater impact on poverty reduction through increased opportunities for off farm job creation through backward and forward linkages.

Finally access to markets is easier in areas with higher population density in particular for small scale farmers.

Impact on local economy (ILE)

Benefits of irrigation projects with small scale farmers are largely reinvested or distributed in the local economy. On the other hand, large commercial farmers tend to reinvest or spend their benefits in urban economy or even outside of the country when the investors are foreigners. This criterion is useful when irrigation investments are seen as mean to alleviate rural poverty.

5.1.3 Environmental and health criterion

The environmental and human health aspects of irrigation schemes are strongly linked because it is changes in the environment in conjunction with socio-economic changes that result in changes in the health of local population. Environmental and health impacts of irrigation development can be both positive and negative and are site specific (see table 5.1).

Other negative environmental impacts are usually associated with irrigation development such as soil salinity, water logging, soil erosion. We have considered that these problems can be adressed by good engineering (design of irrigation and drainage system) and proper operation and management after project completion.

Table 5.1: Examples of positive and negative environmental and health impacts of irrigation development

Positive impacts	
Direct	Indirect
• Improved food security and nutritional status • Improved access to health care • Improved domestic water supply and hygiene	• Empowerment of individuals and communities
Negative impacts	
Direct	Indirect
• Increase of water borne diseases • Contamination of water by agro-chemicals • Occupational exposure to toxic agro-chemicals	• Loss of ecosystems functions and natural resources that benefit people • Conflicts between farmers and pastoralists and between upstream abd down stream communities

5.2 CLASSIFICATION OF INDICATORS

For the financial criterion (FIIR, UCI, EPW and GM), we defined four classes: “poor”, “insufficient”, “good” and “very good”. Each of these classes was attributed a number between one and four as indicated in table 5.2. The classification was done according to common norms and in a manner to discriminate the proposed projects or avoiding all projects fall in one or two classes only.

Table 5.2 Classification of financial criteria

	Poor (1)	Unsatisfactory (2)	Good (3)	Very good (4)
FIRR	< 5%	5% - 10%	10% - 15%	> 15%
UCI (US$/Ha)	> 7,000	5, 500, - 7,000	4,000 – 5,500	< 4,000
EPW (US$/ thousand CM)	> 50	35 - 50	20 - 35	< 20
GM (US$/Ha)	< 400	400 – 800	800 – 1,200	> 1,200

For the socio-economic criteria, we also defined four classes (see table 5.3). Each class is given a number between one and four. Since it is not possible to avail over quantitative indicators for the socio-economic criteria except population density, classification was based on the consultant's knowledge of each irrigation zone through review of existing literature and field visits.

Table 5.3: Classification of socio-economic criteria

	LEI	LSI	Pop	ILE
1	Poor road network and market access	Almost nothing in place	Very low density	Poor, positive
2	Need of investments in roads, long distance to market	Resettlement of population and investment in education and health infrastructures are needed.	Low density	Low, positive
3	Existing roads, markets, no agro-industries	No resettlement of population needed. Poor to acceptable health and social infrastructures	Medium density	Positive
4	Existing roads, markers and agro-industries	Acceptable to good level	High density	High, positive

For the environment and health criterion, we also defined four classes (see table 5.4). The procedure would be similar to the procedure for the SE criteria. Regarding weights SE criteria are at least twice as important as the environmental criteria. The impacts of upstream storage reservoirs and conveyance infrastructure are not included in the MCA which is purely for irrigation. Environmental and health impacts depend on a range of factors such as the size of the irrigation project, biophysical conditions, management and actual use of the water resource, and on the extent to which safeguards measures are introduced. These factors cannot be analyzed in detail at this diagnosis stage and here again classification was based on the consultant's knowledge of each irrigation zone through literature review and field visits.

Table 5.4: Classification of environmental criteria

Classification	Description
1	Severe negative impacts and no or little positive impacts / high mitigation costs
2	Medium negative impacts and no or little positive impacts / substantial mitigation costs
3	Positive impacts and little negative impacts / low mitigation costs
4	Positive impacts and no negative impact / no mitigation costs

Values of the financial indicators are given in table 5.5 and 5.6 for Ethiopia and Sudan.

Table 5.5: Values of financial criteria for Ethiopian projects

Project area	Irrigation zone	W.A	area (Ha)	IC	IRR	EPW	% CF	%SH	GM	DD
Anger & Nekemte	ADF	P	25 670	5 643	15%	51	55%	45%	1 579	Yes
Didessa gravity	ADF	G	52 868	5 740	16%	35	55%	45%	1 579	Yes
Didessa pump	ADF	P	12 903	7 699	12%	48	55%	45%	1 579	Yes
Dinger Bereha	ADF	GP	8 100	7 339	13%	38	55%	45%	1 579	Yes
Kenana	BN-RD	G	420 000	6 407	3%	32	66%	34%	500	No
Rahad 2	BN-RD	G	210 000	6 917	1%	35	66%	34%	500	No
Rahad, Dinder, Galegu	BN-RD	G	55 000	7 795	22%	34	75%	25%	2 006	Yes
Rahad, Dinder,Galegu	BN-RD	P	50 000	8 312	20%	39	75%	25%	2 006	Yes
Wad Miskeen	BN-RD	G	6 000	6 194	3%	32	66%	34%	500	No
Humera, Metema, Angereb	TA	P	71 061	11 202	12%	43	83%	17%	2 053	Yes
Upper Atbara	TA	G	99 000	7 188	1%	18	100%	0%	523	Yes
Gilgel	TB	G	4 998	4 507	10%	29		100%	832	Yes
Gilgel	TB	P	8 558	5 282	8%	38	75%	25%	208	Yes
Gumara	TB	G	12 596	2 068	22%	13		100%	832	Yes
Gumara	TB	P	1 380	14 122	-1%	98		100%	832	Yes
Megech Gravity	TB	G	7 311	3 089	15%	19		100%	832	Yes
Megech P	TB	P	24 510	5 258	7%	40		100%	832	No
NE Tana	TB	P	5 475	7 462	4%	53		100%	832	No
NW Tana	TB	P	6 720	5 774	6%	45		100%	832	No
NW Tana Delgi	TB	P	2 550	5 541	7%	43		100%	832	No
Ribb G	TB	P	9 370	3 819	12%	19		100%	832	Yes
Ribb Pump	TB	P	5 466	7 492	5%	40		100%	832	Yes
SW Tana	TB	P	11 632	5 766	7%	43		100%	832	No
SW Tana Kunzila	TB	P	1 960	6 322	5%	50		100%	832	No
SW Tana Zege	TB	P	6 500	4 991	9%	35		100%	832	No
Upper & Lower Beles	TB	G	147 220	5 187	18%	25	100%	0%	1 470	No
Baro - Akobo projects		P	93 800	3 040	51%	13	100%	0%	2 154	Yes

Table 5.6: Values of financial criteria for projects in Sudan.

Project area	Irrigation zone	W.A	Area (Ha)	UCI	FIRR	EPW	% CF	%SH	GM	DD
Kenana	BN-RD	G	420 000	6 589	2.1%	35	66%	34%	500	No
Rahad 2	BN-RD	G	210 000	7 246	1.4%	35	66%	34%	500	No
Wad Miskeen	BN-RD	G	7 500	6 250	2.4%	40	66%	34%	500	No
Upper Atbara	TA	G	99 000	7 188	1,5%	20	100%	0%	523	Yes

Irrigation zones
ADF: Anger Didessa, Finchaa sub-basins
BN-RD : Blue Nile and Rahad and Dinder Sub-basins
TA: Tekeze and Atbara sub-basins
TB: Tana and Beles sub-basins
W.A: Water abstraction; pumping (P) or gravity (G).
UCI: Unit cost of Infrastructure (US$ /ha)
FIRR: Financial internal rate of return
EPW: Equilibrium price of water (US$ / thousand of m^3)
GM: Gross margin per Ha in cruising years (US$/ha)
% CF: Percentage of total area occupied by commercial farmers
% SH: Percentage of total are occupied by Smallholder farmers
DD: Dam dependant projects: yes or no.

5.3 Ranking of projects for each category of criteria

5.3.1 Ranking of projects with financial criteria only

In Ethiopia, gravity projects are ranked higher than pumping projects. Naturally if investment costs of dams for gravity projects were to be considered, ranking would be very different. The exception are the Baro Akobo projects which are ranked first because of low unit cost of infrastructure and high gross margin per ha because they are fully occupied by commercial farmers. Behind Baro Akobo projects, the best projects are three projects in the Tana and Beles sub-basins: Gumara (gravity), Megech (gravity), Ribb (gravity) and Upper and Lower Beles projects (gravity). The first project in the Didessa growth corridor is Didessa gravity project. Gravity projects located in Rahad and Dinder sub-basins are financially interesting because they are largely based on commercial farmers with 75% of the total area occupied by commercial farmers.

In Sudan, there are no significant differences between projects. Rahad 2 project is behing the three others because of its lower equilibrium price of water. More clearly, irrigation water is more expensive in Rahad 2 projects than in the other projects.

Table 5.7: Ranking of Ethiopian projects with financial criteria only.

Project area	Irrigation zone	W.A	area (Ha)	IRRR	IC	EPW	GM	Mean	DD	Rank
Baro&Akobo projects		P	93 800	4	4	4	4	4,0	Yes	1
Gumara gravity	TB	G	12 596	4	4	4	3	3,8	Yes	2
Megech gravity	TB	G	7 311	3	4	4	3	3,5	Yes	3
Ribb G	TB	G	9 370	3	4	4	3	3,5	Yes	3
Upper & Lower Beles	TB	G	147 220	4	3	3	4	3,5	No	3
Rahad, Dinder, Galegu, G	BN-RD	G	55 000	4	1	3	4	3,0	Yes	6
Gilgel Gravity	TB	G	4 998	3	3	3	3	3,0	Yes	6
Didessa G	ADF	G	52 868	3	2	2	4	2,8	Yes	8
Rahad, Dinder,Galegu, P	BN-RD	P	50 000	4	1	2	4	2,8	Yes	8
Anger & Nekemte	ADF	P	25 670	3	2	1	4	2,5	Yes	10
Didessa pump	ADF	P	12 903	3	1	2	4	2,5	Yes	10
Dinger Bereha	ADF	GP	8 100	3	1	2	4	2,5	Yes	10
Humera, Metema, Angereb	TA	P	71 061	3	1	2	4	2,5	Yes	10
Megech P	TB	P	24 510	2	3	2	3	2,5	No	10
NW Tana Delgi	TB	P	2 550	2	3	2	3	2,5	No	10
SW Tana Zege	TB	P	6 500	2	3	2	3	2,5	No	10
NW Tana	TB	P	6 720	2	2	2	3	2,3	No	17
SW Tana	TB	P	11 632	2	2	2	3	2,3	No	17
SW Tana Kunzila	TB	P	1 960	2	3	1	3	2,3	No	17
Gilgel pumping	TB	P	8 558	2	3	2	1	2,0	Yes	20
Ribb Pump	TB	P	5 466	2	1	2	3	2,0	Yes	20
Gumara pumping	TB	P	1 380	1	1	1	3	1,5	Yes	22
NE Tana	TB	P	5 475	1	1	1	3	1,5	No	22

Table 5.8: Ranking of projects in Sudan with financial criteria only

Project area	Irrigation zone	W.A	area (Ha)	IRR	IC	EPW	GM	Mean	rank	DD
Kenana	BN-RD	G	420 000	1	2	3	2	2.0	1	No
Wad Miskeen	BN-RD	G	7 500	1	2	3	2	2.0	1	No
Upper Atbara	TA	G	99 000	1	1	4	2	2.0	1	Yes
Rahad 2	BN-RD	G	210 000	1	2	2	2	1.8	2	No

5.3.2 Ranking of projects with socio-economic criteria only

In Ethiopia, Lake Tana shores are ranked first (11 best projects are located on the Lake Tana shores, see table 5.9.). This explains easily as these projects involve only small scale farmers in a highly populated zone. Impacts on local economy and poverty reduction are thus high. Differences in ranking of Lake Tana shores projects are due to financial criteria. Best projects are Gumera (gravity), Megech (gravity) and Ribb (gravity). The fist project in the Didessa basin growth corridor is Didessa gravity project. Projects in the Rahad, Dinder sub-basins and Tekeze basin are ranked in last position because of poor potential impact on poverty reduction and low level of economic and social infrastructures in these zones. In Sudan, here again there are no really significant differences amongst projects. Upper Atbara is ranked last because of its lower impact on poverty (less population in the area and commercial farms only, see table 5.10).

Table 5.9 Ranking of Ethiopian projects with socio-economic criteria only

Project area	**Irrigation zone**	**W.A**	**area (Ha)**	**LEI**	**LSI**	**Pop**	**ILE**	**Mean**	**rank**	**DD**
Gilgel Gravity	TB	G	4 998	3	3	4	4	3,5	1	
Gilgel pumping	TB	P	8 558	3	3	4	4	3,5	1	Yes
Gumara gravity	TB	G	12 596	3	3	4	4	3,5	1	Yes
Gumara gravity	TB	G	1 380	3	3	4	4	3,5	1	No
Megech gravity	TB	G	7 311	3	3	4	4	3,5	1	Yes
Megech Pumping	TB	P	24 510	3	3	4	4	3,5	1	No
NW Tana	TB	P	6 720	3	3	4	4	3,5	1	No
NWTana Delgi	TB	P	2 550	3	3	4	4	3,5	1	No
Ribb Gravity	TB	G	9 370	3	3	4	4	3,5	1	Yes
Ribb Pump	TB	P	5 466	3	3	4	4	3,5	1	Yes
SW Tana	TB	P	11 632	3	3	4	4	3,5	1	No
SW Tana Kunzila	TB	P	1 960	3	3	4	4	3,5	1	No
SW Tana Zege	TB	P	6 500	3	3	4	4	3,5	1	No
NE Tana	TB	P	5 475	3	3	4	2	3,0	14	No
Anger & Nekemte	ADF	P	25 670	2	2	2	3	2,3	15	Yes
Didessa Gravity	ADF	G	52 868	2	2	2	3	2,3	15	No
Didessa Pumping	ADF	P	12 903	2	2	2	3	2,3	15	Yes
Dinger Bereha	ADF	GP	8 100	2	2	2	3	2,3	15	Yes
Upper & Lower Beles	TB	G	147 220	1	1	2	1	1,3	18	No
Baro&Akobo projects		P	93 800	1	1	2	1	1,3	18	Yes
Rahad, Dinder, Galegu	BN-RD	G	55 000	1	1	1	1	1,0	20	Yes
Rahad, Dinder, Galegu	BN-RD	P	50 000	1	1	1	1	1,0	20	Yes
Humera, Metema, Angereb	TA	P	71 061	1	1	1	1	1,0	20	Yes

Table 5.10: Ranking of projects in Sudan with socio-economic criteria only

Project area	Irrigation zone	W.A	area (Ha)	LEI	LSI	Pop	ILE	Mean	rank	DD
Kenana	BN-RD	G	420 000	4	4	3	3	3,5	1	No
Wad Miskeen	BN-RD	G	7 500	4	4	3	3	3,5	1	No
Rahad 2	BN-RD	G	210 000	4	4	3	2	3,3	3	Yes
Upper Atbara	TA	G	99 000	3	3	2	3	2,8	4	No

5.3.3 Ranking of projects with environmental criterion only

In Ethiopia Lake Tana shore projects are ranked last because of their potential negative impacts on wetland and recession agriculture, fisheries and pollution of the lake. Projects in Anger-Didessa–Fincha sub-basin are ranked first. The zone is a growth corridor where potential positive impacts are high. Negative and positive impacts of projects in Baro-Akobo and Tekeze sub-basins are potentially low, however they bear the risk of conflicts with pastoralists. In Sudan, the potential impacts of projects is low and all projects can be given 3 for the environmental criterion.

Table 5.11: Ranking of Ethiopian projects according to the environmental criterion

Project area	**Irrigation zone**	**W.A**	**area (Ha)**	**EC**	**rank**	**DD**
Anger & Nekemte	ADF	P	25 670	4	1	Yes
Didessa Gravity	ADF	G	52 868	4	1	Yes
Didessa Pump	ADF	P	12 903	4	1	Yes
Dinger Bereha	ADF	GP	8 100	4	1	Yes
Rahad, Dinder, Galegu	BN-RD	G	55 000	3	5	Yes
Rahad, Dinder, Galegu P	BN-RD	P	50 000	3	5	Yes
Humera, Metema, Angereb	TA	P	71 061	3	5	Yes
Upper & Lower Beles	TB	G	147 220	3	5	No
Baro&Akobo projects		P	93 800	3	5	Yes
Gilgel Gravity	TB	G	4 998	2	6	Yes
Gilgel Pump	TB	P	8 558	2	6	Yes
Gumara gravity	TB	G	12 596	2	6	Yes
Gumara pumping	TB	P	1 380	2	6	Yes
Megech Gravity	TB	G	7 311	2	6	Yes
Megech Pump	TB	P	24 510	2	6	No
NE Tana	TB	P	5 475	2	6	No
NW Tana	TB	P	6 720	2	6	No
NW Tana Delgi	TB	P	2 550	2	6	No
Ribb Gravity	TB	G	9 370	2	6	Yes
Ribb Pump	TB	P	5 466	2	6	Yes
SW Tana	TB	P	11 632	2	6	No
SW Tana Kunzila	TB	P	1 960	2	6	No
SW Tana Zege	TB	P	6 500	2	6	No

5.4 Multicriteria analysis

For the multicriteria analysis we have considered:

- Financial criteria are the most important one as very often international development only consider them for deciding wether or not a project is worth implementing. Moreover, projects with good financial indicators are more likely to offer opportunities for poverty reduction through increased on-farm incomes, employment creation and forward andbackward linkages. They are also more likely to bear the mitigation costs of negative environmental and health impacts.

- Socio economic criteria come second, or in other words they should discriminate projects with similar results financial criteria .

- Finally the environmental and health criterion comes third, project with similar impact on economic growth and social benefits should be discriminated by their environmental and health impact.

The above translates in quantitative terms by weighting the financial criteria (4) or twice as much as the socio-economic criteria(2) or four times as much as the environmental and health criterion (1). Results are given in tables 5.12 and 5.13 for Ethiopia and Sudan respectively.

In Ethiopia, the gravity projects come on top of he list because of their good financial criteria, but it must be reminded here that these projects are dependant on damconstruction, costs of dams are were not included in this analysis. Regarding pump-fed irrigation projects, lake tana shore projects come first because of good financial criteria and their potential high impact on poverty reduction in this highly densely populated area. For the environmental and health criterion we have considered only impact of individual projects separately, but implementation of all these projects pumping water in Lake Tana might result in catastrophic impact regarding the lake water balance and ecology. So far only Megech, ranked 8 and first pump-fed project, is committed. For ENIDS suitable projects, i.e. not exceeding 7 500 Ha net area, not committed, and not suspended, Dinger Bereha project is ranked first and should be recommended for feasibility study in phase 2 of ENIDS. In Sudan, only Wad Miskeen project can be recommended for feasibility study.

Table 5.12 Results of multicriteria analysis for Ethiopian projects

Project area	Irrigation zone	area (Ha)	FC		SEC		EC		Total	Rank	DD
			Value	Weight	Value	weight	Value	weight			
Gumara gravity	TB	12 596	3,8	4	3,5	2	2,0	1	24,2	1	Yes
Megech gravity	TB	7 311	3,5	4	3,5	2	2,0	1	23,0	2	Yes
Ribb G	TB	9 370	3,5	4	3,5	2	2,0	1	23,0	2	Yes
Baro&Akobo projects	BA	93 800	4,0	4	1,3	2	3,0	1	21,6	4	Yes
Gilgel G	TB	4 998	3,0	4	3,5	2	2,0	1	21,0	5	Yes
Didessa G	ADF	52 868	2,8	4	2,3	2	4,0	1	19,8	6	Yes
Upper& Lower Beles	TB	147 220	3,5	4	1,3	2	3,0	1	19,6	7	No
Megech Pump	TB	24 510	2,5	4	3,5	2	2,0	1	19,0	8	No
NW Tana Delgi	TB	2 550	2,5	4	3,5	2	2,0	1	19,0	8	No
SW Tana Zege	TB	6 500	2,5	4	3,5	2	2,0	1	19,0	8	No
Anger & Nekemte	ADF	25 670	2,5	4	2,3	2	4,0	1	18,6	11	Yes
Didessa Pump	ADF	12 903	2,5	4	2,3	2	4,0	1	18,6	11	Yes
Dinger Bereha	ADF	8 100	2,5	4	2,3	2	4,0	1	18,6	11	Yes
NW Tana	TB	6 720	2,3	4	3,5	2	2,0	1	18,2	11	No
SW Tana	TB	11 632	2,3	4	3,5	2	2,0	1	18,2	11	No
SW Tana Kunzila	TB	1 960	2,3	4	3,5	2	2,0	1	18,2	11	No
Rahad, Dinder,Galegu G	BN-RD	55 000	3,0	4	1,0	2	3,0	1	17,0	17	Yes
Gilgel P	TB	8 558	2,0	4	3,5	2	2,0	1	17,0	17	Yes
Ribb Pump	TB	5 466	2,0	4	3,5	2	2,0	1	17,0	17	Yes
Rahad, Dinder,Galegu P	BN-RD	55 000	2,8	4	1,0	2	3,0	1	16,2	20	Yes
Humera, Metema, Angereb	TA	71 061	2,5	4	1,0	2	3,0	1	15,0	21	Yes
Gumara pumping	TB	1 380	1,5	4	3,5	2	2,0	1	15,0	21	Yes
NE Tana	TB	5 475	1,5	4	3,0	2	2,0	1	14,0	23	No

Table 5.13: results of multicriteria nalysis for projects in Sudan.

Project area	Irrigation zone	area (ha)	FC		SEC		EC		Total	Rank	DD
			Value	Weight	Value	weight	Value	weight			
Kenana	BN	420 000	2,0	4	3,5	2	3,0	1	18,0	1	Yes
Wad Miskeen	BN	7 500	2,0	4	3,5	2	3,0	1	18,0	1	Yes
Rahad 2	BN	210 000	1,8	4	3,3	2	3,0	1	16,8	3	Yes
Upper Atbara	TA	99 000	2,0	4	2,8	2	3,0	1	16,6	4	Yes

BIBLIOGRAPHY

ETHIOPIA

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

2. ARBID Executive Summary, BECOM & BRGM, 1999.

3. ARBID Phase 3 Pre-feasibility Study, Part 1 Irrigation and Drainage-Gilgel Projects, BCEOM & BRGM, 1998.

4. ARBID Phase 3 Pre-feasibility Study, Part 3 Irrigation and Drainage- Megech, BCEOM & BRGM, 1999.

5. ARBID Phase 3 Pre-feasibility Study, Part 4 Irrigation and Drainage- North East Lake Tana, BCEOM & BRGM, 1999.

6. ARBID Phase 3 Pre-feasibility Study, Part 5 Irrigation and Drainage- Ribb, BCEOM & BRGM, 1999.

7. ARBID Volume V-Water Resources Part 1 Irrigation & Drainage, BCEOM & BRGM, 1999.

8. ARBID Volume IX Land Resources Development Part 2 Semi Detailed Soil Survey, BCEOM & BRGM, 1999.

9. ARBID Volume X Land Resources Development Part 3 to 5 Land Cover/Use, Evaluation & Agro-ecology, BCEOM & BRGM, 1999.

10 ARBID Volume XI Land Resources Development Part 6 Agriculture, BCEOM & BRGM, 1999,

Ditto Volume XIII Environment Part 4

Ditto Volume XV Agro-Socio-economic Survey and Analysis

11. ARBID Phase 2 section 1-Main Report Data Collection, Site Investigation & Survey and Analysis, BCEOM & BRGM, 1999.

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

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

14. Tekeze River Basin Integrated Development Master Plan (TRBIDMP), Executive Summary, NDECO, 1998.

15. TRBIDMP, Volume XI Natural Resources, Land Cover/Use, Agriculture, Livestock & Fishery, NDECO, 1998.

16. TRBIDMP Volume X, Water Resources, WR5 Irrigation, NDECO, 1998.

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

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

SUDAN

19. Buraymah ,I. 2008 Soil report of the proposed Rahad phase II Project Pilot area. LWRC/ARC/Wad Medani – Sudan.

20. Coyne B. Alexander Gibb. Hunting Technical Service 1977. Blue Nile Waters Study. Min. of Irrig. Khartoum. Sudan.

21. FAO. 1974. A Framework for Land Evaluation Bull. No. 32. Rome.

22. Husam Farah. 1973. Reconnaissance Soil Survey in the Upper Atbara Area. SSD. Wad Medani, Sudan.

23. Kevie and Buraymah (1976) Exploratory Soil Survey Kassala Province – SSA. Report No. 73 Wad Medani, Sudan.

24. Soil Survey Staff 1999. Soil Taxonomy, Agric Handbook No. 436 2nd edition. SCS. Washington D.C., USA.

25. Mohamed El Hassan Abdel Karim. 1994. Rahad Irrigated Project (Phase II) South of Jebel Fau Area. Semi detailed soil survey, land evaluation and land use survey. Soil Survey Administration, Report 142. Wad Medani.

26. Coyne et Bellier, 1978. Blue Nile Waters Study. Phase IA. Availability and use of Blue Nile Water. Volume 2. Supporting Report. I Soils. Coyne et Belier / HTS / MMP / Gibb. Khartoum: Ministry of Irrigation and Hydro-Electric Energy.

27. HTS, 1966. Roseires Soil Survey. The Guneid and Hawata Extensions to the Rahad Project. Soil Survey and Land Classification. Report No 13. London: HTS / MMP.

28. Bunting, A.H. and J.D. Lea, 1962 : The Soils and Vegetation of the Fung, East Central Sudan. *Journal of Ecology*, 50, 3, 529-558.

29. Coyne et Bellier et al, 1978: *Blue Nile Waters Study. Phase IA. Availability and Use of Blue Nile Water*. Main Report. Coyne et Belier, Hunting Technical Services Ltd., Sir Alexander Gibb and Partners, Sir M MacDonald and Partners. Khartoum: Ministry of Irrigation and Hydro-Electric Energy.

30. Coyne et Bellier et al, 1978: *Blue Nile Waters Study. Phase IA. Availability and Use of Blue Nile Water*. Volume 2. Supporting Report. I Soils and Supporting album of land suitability maps at 1:100,000 scale. Coyne et Belier, Hunting Technical Services Ltd., Sir Alexander Gibb and Partners, Sir M MacDonald and Partners. Khartoum: Ministry of Irrigation and Hydro-Electric Energy.

31. Coyne et Bellier et al, 1979: *Nile Waters Study.* Main Report. Coyne et Belier, Hunting Technical Services Ltd., Sir Alexander Gibb and Partners, Sir M MacDonald and Partners. Khartoum: Ministry of Irrigation and Hydro-Electric Energy.

32. Doughtery, T.C. and Wall, A.W., 1995 : Environmental impact assessment of irrigation and drainage projects. *FAO Irrigation and Drainage Paper*, 53. Rome: Food and Agricultural Organization.

33. Fadul, H. M., 1993 : Semi detailed soil survey and land evaluation of the Proposed Great Kenana Irrigated Scheme. *Soil Survey Administration Report* 134. Wad Medani: Soil Survey Administration (now Land and Water Research Centre).

34. FAO, 1970a : *Report to the Government of Sudan on Strengthening of the Soil Survey Division of the Ministry of Agriculture*. Reconnaissance Soil Surveys of Parts of the Central Clay Plain. AGL:SF/SUD 15. Technical Report 2. Rome: Food and Agricultural Organization.

35. FAO, 1970b : *Report to the Government of Sudan on Strengthening of the Soil Survey Division of the Ministry of Agriculture*. Semidetailed Soil Survey of Parts of the Central Clay Plain. AGL:SF/SUD 15. Technical Report 3. Rome: Food and Agricultural Organization.

36. Hunting Technical Services, 1966 : Blue Nile West Bank Abu Hagar to Sennar. Semi-Detailed Soil Survey. Area 2b. Report No. 12, Volume III. Roseires Soil Survey. Ministry of Agriculture, Republic of Sudan. London: Hunting Technical Services Ltd. and Sir M MacDonald and Partners, London.

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APPENDICES

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