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EASTERN NILE IRRIGATION AND DRAINAGE STUDY/FEASIBILITY STUDY
FINAL REPORT WAD MESKIN PROJECT

MAIN REPORT

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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 ha

ABBREVIATIONS

ADB/F	African Development Bank/Fund
AGS	Addis Geo Systems
ANRS	Amhara National Regional State
API	Aerial Photo Interpretation
ARBID/MPS	Abbay River Basin Integrated Development Master Plan
ASTM	American Society for Testing of Materials
BCM	Billion Cubic Meters = 1 km^3
B/C ratio	Benefit Cost ratio
BH	Borehole
BS	British Standards
CEC	Caution Exchange Capacity
CS	Complementary Surveys
DC	Direct electrical current
DIU	Dams Implementation Unit (Sudan)
DOCS	Date of Commencement of Services
dS/m	deci-Siemens per meter
d/s	downstream
EC	Electrical conductivity
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMA	Ethiopian Mapping Agency
EMP	Environmental Management Plan
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
EPMS	Environmental Protection Monitoring Strategy
ESP	Exchangeable Sodium percentage
ESCP	Ethiopian Standard Code of Practice
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
GPS	Geographical Positioning System
GRP	Glass reinforced polyester
GTZ	German Technical Cooperation Agency
Ha	hectare
HDPE	high density poly ethylene
HP	hydro power
HQ	High Quality (classification for drilling core)
ICCON	International Consortium for Co-operation on the Nile
ICT	International Consultants and Technocrats Pvt Ltd.
IEE	Initial Environmental Examination
ISL	Isambert Salembier Lino Consultants
LUT	Land Utilisation Type
LUR	Land Use Requirement
masl	Meters above sea level
MC	Main Conveyor
MCA	multi-criteria analysis
mcm	Million Cubic Meters
MoIWR	Ministry of Irrigation and Water Resources (Sudan)
MoWR	Ministry of Water Resources (Ethiopia)
mS	micro Siemens
N1, N2	Land suitability classes
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
NQ	Normal Quality (classification of drilling core)
OIDA	Oromiya Irrigation Development Authority
ONRS	Oromya National Regional State
O&M	Operation and Maintenance
P	Pumping
PA	Peasant Association
PF	Pre-feasibility
PFS	Pre-feasibility Study
PMO	Project Management Office
PS	Pump station
RfP	Request for Proposal
RQD	Rock Quality Designation
S1, S2, S3	Land suitability classes
SAP	Subsidiary Action Programmes
SAR	Sodium Adsorption Ration
SEIA	Social and Environmental Impact Assessment
SDS	Small Disturbed Sample
SPT	Standard Penetration Test
SPT-N	Standard Penetration Test-Normal
SVP	the Shared Vision Programme
TAMS	Tippets-Abbett-McCarthy-Stratton Engineers and Architects
tc	ton of cane
T_c	time of concentration (only used in hydrological calculations)
TCC	Technical Coordinating Committee
TDS	Total Dissolved Solids
TLU	Tropical Livestock Unit (metabolic weight equivalence)
TOR	Terms of Reference
TRBID/MPS	Abbay River Basin Integrated Development Master Plan
TTB2	a set of geological formations
UA	Unit of Account
u/s	upstream
USBR	United States Bureau of Reclamation
UTM	Universal Trans Mercator
VES	Vertical Electric Sounding
WAPCOS	Water and Power Consultancy Services (India) Ltd.
WB	World Bank
WRMP	Water Resources Management Policy
WUA	Water Users Association
WWD&SE	Water Works Design and Supervision Enterprise

1. Preface

The Feasibility Study (FS) report for the Dnger Bereha Irrigation Project (herein after named 'the Project') comprises one main report and six volumes of annexes, maps and drawings and has been prepared in accordance with the requirements of the contract for the Feasibility Study Phase 2 of the Engineering Component of the Eastern Nile Irrigation and Drainage Study (ENIDS), concluded between the Eastern Nile Technical Regional Office (ENTRO), the Client and BRLi, Metaferia Consultants and Shoraconsult, respectively for the Dinger Bereha project site in Ethiopia and the Wad Meskin project site in Sudan.

The following volume is the Main Report.

2. INTRODUCTION

2.1 STUDY CONTEXT

The Nile Basin Initiative (NBI) was established in 1999 by the ten Nile Riparian States[1] as a co-operative programme to address poverty, environmental degradation and instability in the Nile Basin while promoting socio-economic development. The African Development Bank was represented at the launching of the International Consortium for Co-operation on the Nile (ICCON) which took place in Geneva, 26-28 June 2001, and on that occasion, committed itself to support the Nile countries in their effort "to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources"[2]. In order to transform their Vision to action, the Nile Riparian countries developed a Strategic Action Programme which is being implemented through two complementary programmes: (i) the Shared Vision Programme (SVP) and (ii) the Subsidiary Action Programme (SAP). The SVP seeks to build trust among the states, improve implementation capacity and lay the foundations for cooperative investment and development. The SAP is oriented towards investment projects at the sub-basin level, involving all potentially affected states.

Two sub-basin Subsidiary Action Programmes (SAP) have been initiated, covering respectively the Eastern Nile and the Nile Equatorial Lakes regions. Egypt, Ethiopia and Sudan form part of the Eastern Nile Subsidiary Action Programme (ENSAP) under the Eastern Nile Council of Ministers of Water Affairs (ENCOM) while Burundi, Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda form part of the Equatorial Lakes Subsidiary Action Programme (NELSAP). The goal of the ENSAP and the NELSAP are to develop the water resources of the Eastern Nile Basin and of the Equatorial lakes Basin respectively in a sustainable and equitable way to ensure prosperity, security, and peace for the whole Nile basin. The Eastern Nile Irrigation and Drainage Study (ENIDS) project, hereinafter named 'the Study' aims at contributing to the enhancement of food security, reduction of rural poverty, and reduction of population pressures in the region, with all associated beneficial effects on the environment. The study will contribute to attaining the agricultural sector goals of the participating countries (Egypt, Ethiopia and Sudan), towards 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.

The Study has two components:

- Engineering Sub-component that has identified a total of 15,000 ha (net) in Ethiopia and Sudan from among the proposed potential sites and has undertaken a feasibility study for irrigation development.
- The Cooperative Regional Assessment (CRA) that has:
  - prepared guidelines for the identification and selection of irrigation and drainage projects presenting regional benefits;
  - undertaken assessment of the need for institutional and legislative reforms; and
  - proposed a cooperative framework and a common agenda on irrigation development in the Eastern Nile Basin (Egypt, Ethiopia and Sudan) for the medium and long term.

1 The ten Nile countries are Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eritrea currently holds an observer position.

2 Vision of the NBI

The Inception Phase of the Study commenced in September 2007. The findings of this phase indicated that there was a need to undertake detailed field surveys related to soils, topography and geotechnical investigations that would be a critical input to the Phase 2 Feasibility study under the Engineering sub-component. However, the sites would have to be selected first during Phase 1 of the Engineering Study.

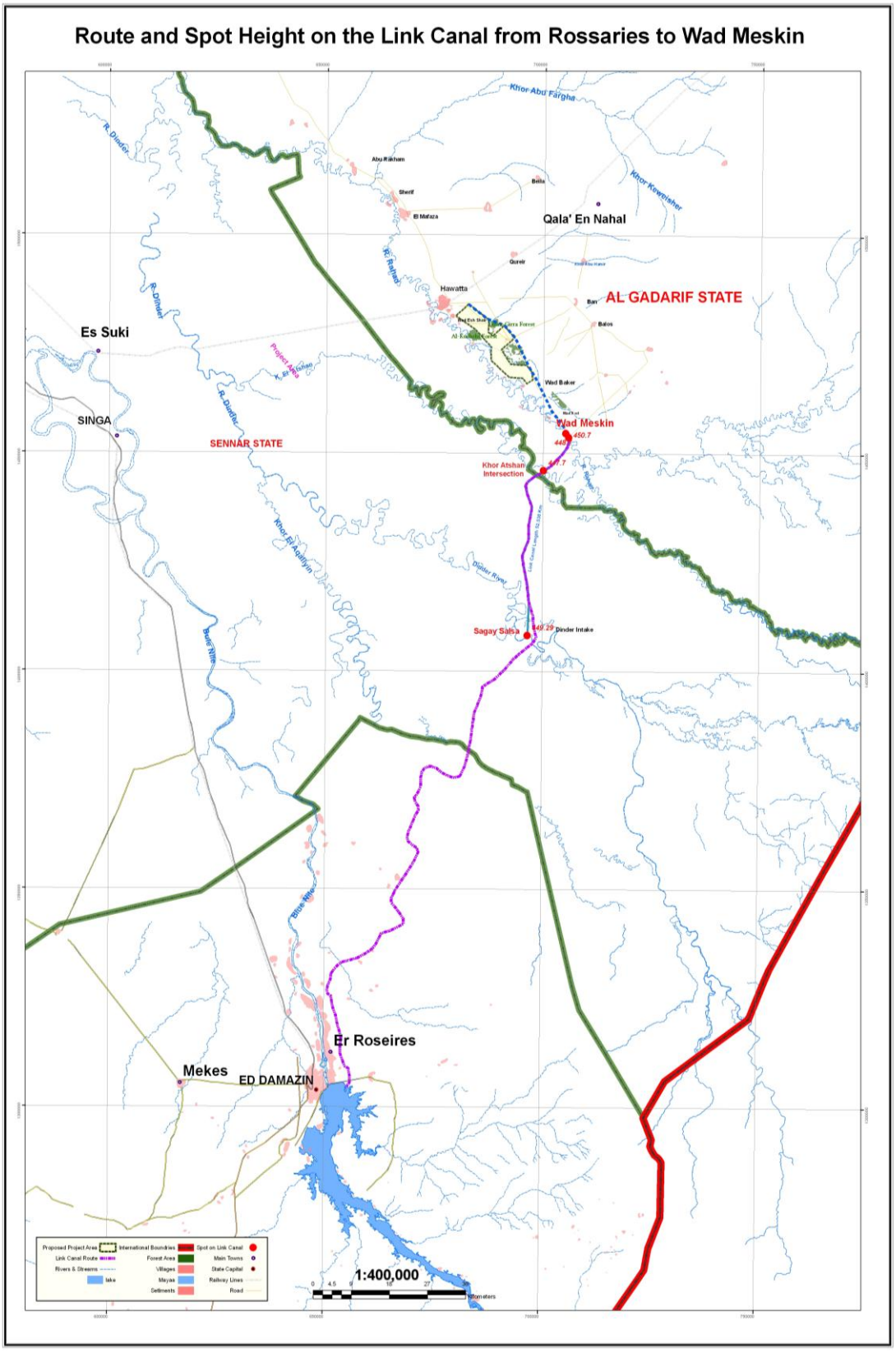
2.2 Phase 1 Diagnosis of Engineering Study and Identification and Selection of Potential Site

BRLi of France and Shoraconsult of Sudan (hereinafter named ' the Consultant') have been working on the Eastern Nile Irrigation and Drainage Study (ENIDS) since September 2007. During the Diagnosis Phase a large number of project sites in both countries were described, compared and ranked on basis of a number of criteria. The results have been presented in the respective reports. The analysis showed that all projects identified in Sudan (Rahad II, Kenana, Atbara) and ranked were already under study at feasibility level. Subsequently the National Coordinator at the Ministry of Irrigation and Water Resources (MoIWR) proposed to study the Wad Meskin project area, located on the right bank of the Rahad River and south-east of Hawata. This area is the most southern tip of the Rahad II area and development for supplementary irrigation in this area could provide experience, important for the development of the Rahad II project. The Consultant carried out a brief study on this site and quickly came to the conclusion that the site was suitable for irrigation development, but feasibility of improved rainfed cultivation with supplementary irrigation from Rahad River would not be feasible unless dry season irrigation with water from other sources would be made possible in later stages. The only large scale dry season source would be the Blue Nile. Water could be either conveyed by a pump station and pumpcanal or by the gravity from Roseires Dam via the proposed Roseires Canal. An alternative project site was proposed by the Consultant and considered by MoIWR who indicated that it preferred to continue with the study on Wad Miskeen with the understanding that future dry season water supply would be provided by the Roseires Canal. At the time, the alignment of this canal was under study by the Dams Implementation Unit (DIU). The Consultant indicated that whichever alignment was selected the Wad Miskeen project could benefit from the Roseires Canal.

In the Phase 1 Engineering Report, the Consultant's findings indicated that the sites proposed for feasibility study were the Dinger Bereha area in Ethiopia and the Wad Miskeen project, in Rahad II area in Sudan. The precise boundaries would have to be determined during the Inception Phase of the additional investigationsAdditional Investigations and Development Options. The proposed project is about 7,500 ha net and lies in the southern end of Rahad II (see Map 1). It lies between Hawata town and Wad Meskin on the eastern side of the seasonal Rahad River. The defunct railway line from Khartoum to Gedarif then Port Sudan crosses the Rahad River at Hawata which lies on the northern end of the project. The Wad Meskin Project site is close to the Rahad **Pr**oject Phase II which lays within latitudes 13º - 40´ and 15º - 10´ and longitude 33º - 40´ to 34º - 20´ E. The project area is located on the eastern bank of Rahad River and its land is shared between Gezira and Gaderif States. Water for supplementary irrigation would be provided by a barrage on Rahad River, just upstream of Wad Miskeen village and a main canal. In the future, this canal would be enlarged and extended to the Rahad II area north of Hawata, whereas the supply of water for wet season cultivation would be increased by a new barrage on Dinder River and a link canal to the Wad Miskeen barrage. To ensure sufficient command, the and the link canal would have to be located as much as possible on the Roseires canal alignment surveyed by McDonald in the sixties. Part of this alignment, upstream of the site is located in the Dinder Park, not far from the NW and SW boundaries

The link canal and the barrages would then become part of the system to provide dry season irrigation water to Rahad II from Roseires Reservoir, where the dam is now being heightened. Therefore, the NC and the Consultant agreed to investigate potential locations for the two barrages and the link canal during the additional investigations phase.

Map 1: Location of Project Area, barrage sites and link canal



2.3 ADDITIONAL INVESTIGATIONS AND DEVELOPMENT OPTIONS

ENTRO made arrangements, intended to prepare soil and topographic maps as well as to undertake geotechnical investigations of the sites selected for feasibility study. The terms of reference of the surveys were prepared during the beginning of 2008, and after funding was committed by the AfDB, a RFP was issued in March 2008. Proposals were submitted in July 2008 by a number of selected consulting firms and after evaluation, selection and negotiations a contract was signed in January 2009 by ENTRO, the Client, and the Joint Venture BRLi, Shoraconsult and Metaferia Consulting Engineers (MCE).

The identification of sites with a total area of 15,000 ha (net) for feasibility study among the proposed potential sites was finalized in September 2008, after the locations of the sites were determined.

As per the Phase 1 Engineering Report, the Consultant's findings indicated that the sites proposed for feasibility study were the Dinger Bereha area, in Ethiopia and the Wad Miskeen project, in Rahad II area in Sudan. The precise boundaries were to be determined during the Inception Phase of the Field Investigations Study. The Consultants investigated a number of potential sites for the Rahad and Dinder Barrages and the link canal alignment following McDonald and concluded that the McDonald site for Rahad barrage and most of the link canal alignment could be retained. The McDonald Dinder siphon crossing was not found suitable for a barrage, but downstream, on the border of the park a suitable place was found where command was still sufficient to divert water into the link canal. Together with the Khor Atchan crossing in the link canal, the coordinates of the sites were determined for the surveys to be carried out during the additional investigations phase. Inception Reports were prepared and the final version of these reports was approved in May 2009. The surveys, laboratory work, mapping and reporting were carried out between the end of April and the end of October. Part of the geotechnical investigations in Sudan could not be completed because fieldwork had to be suspended due to inaccessibility of part of the study area during the rainy season and water in Rahad River. In spite of the best efforts of the Consultants this could not be avoided, as the start of the fieldwork was delayed due to circumstances beyond the control of the Consultant. Fieldwork would be continued as soon as the sites would become accessible again, which was expected to be in the beginning of November 2009. However, geotechnical field work could not be restarted before the end of January 2010 because of presence of water in Rahad River.

2.4 PROJECT OUTLINE

Wad Meskin barrage across Rahad River has been planned to regulate the flood flows during rainy season, for Dinder and Rahad Rivers so as to satisfy the needs of Rahad Project Phase I, through Abu Rakham barrage as a downstream regulator, and to divert water to Rahad Project Phase II for summer crops through a main canal.
This same barrage would regulate water transported from the Roseires Dam, after the heightening project completion, with the link canal through Dinder River barrage to the project. The site for the proposed barrage across Dinder River has been selected. Originally a siphon was proposed to pass the Roseires canal under Dinder River. It is essential to note that, these irrigation structures *"Rahad and s the link canal and the main canal"* to be built at this supplementary irrigation phase are part of the requirements of the irrigation system needed after heightening Roseires dam. That is to say when the whole potential area planned to be developed "185,000 ha" is implemented. With the results of the additional investigations it was possible to prepare cost estimates and make feasibility calculations for the following scenario:

1) Phase 1 would comprise the implementation of the 7,500 ha net Wad Miskeen project, the Rahad Barrage and a 10 m^3/s feeder canal. These developments are only intended to improve rainfed agriculture.

2) Phase 2 would comprise the implementation of 100,000 ha, to be irrigated with water diverted from Dinder River by Dinder Barrage to a 100 m^3/s canal linking Dinder and Rahad Rivers. The Wad Miskeen feeder and main canal would be enlarged and extended.

3) Phase 3 would comprise the construction of the Roseires Canal possibly upto the Dindir Barrage, where it would be linked to the Phase 2 conveyance system. This, however depends on whether the Mc Donald alignment of the Roseires canal which skirt the Dinder Park will be accepted by the Government.

This report presents the findings of the feasibility calculations carried out according to the above development scenario. It is noted that no information could be obtained from the DIU regarding their studies on the Roseires Canal alignment. Therefore, it was impossible for the Consultant to integrate DIU's findings and recommendations.

3. BACKGROUND

3.1 SUDANESE ECONOMY

3.1.1 General

Sudan is the largest country in Africa by land area, it had an estimated population of 39.2 million in 2008. It borders 9 different countries and has a coast line of approx 900 km on the Red Sea. Sudan has many different peoples, languages and cultures. Numerically no one group dominates, but in practice there is considerable inequality between a centre, dominated by people from Khartoum and the North, particularly the population living along the Nile, and a far larger periphery. From 1993, the government has promoted an economic liberalization policy. Main features were price liberalization of goods and services, privatization of public enterprises, reforming government tax system by broadening its collection base, and harnessing the monetary inflation policies. By 2001, the government abolished all types of agricultural taxes including profit taxes, agricultural export taxes, limiting the minimum import tariff on agricultural inputs to 3 percent. Sudan's 2005 Comprehensive Peace Agreement (CPA) is a major opportunity to turn the devastation of years of war, population displacement, and underdevelopment in war affected areas into a new era of peace and prosperity. It directly addresses the key causes of the conflict, and laid out the parties' vision and commitment to accelerating development most particularly in Southern Sudan. The Government began by 2006 supporting the agricultural insurance and risk averse Fund program to bring stability in the sector.

3.1.2 Petroleum led recent economic growth

The Sudanese economy grew at over 8% in recent years, bolstered by higher oil production and a continuing boom in construction and services. Sudan's per capita income rose from 354 US dollars in 2000 to 1,413 US dollars in 2007. Economic expansion was financed by the oil revenues, but more recently spending has outpaced the growth in revenues, with rapid increases in most categories of spending. As a consequence, planned public investments, including in the water sector, have been very recently revised down. Non-oil economic growth is driven by the service sectors and remains vulnerable to reduced public consumption and investment. Inflation has remained below 10 percent in recent years, down from 130 percent in 1996. The impact of the 2009 world crisis has been felt nationally, but most strongly in the South, where oil constitutes 97% of revenue. Today the agricultural sector contributes to approx 26% of the GDP down from 46% in 2000 (see table 3.1).

3.1.3 Trade

Sudan experienced stability in the exchange rate since 1998. The exports of Sudan continued to increase recording surpluses in the balance of payments until 2001, but then dropped onwards due to large expansion in imports for construction and services activities.

The balance of trade in agriculture was also negative for many years due to increasing imports of food and other agricultural related items. For many years, the agricultural exports have not been able to cover the cost of imports of the main food commodities such as wheat and edible oil.

Table 3.1 Major economic indicators for Sudan in 2000 and 2007

Economic indicators	2000	2007
GDP (billion USD)	12.37	58.44
GDP growth (annual %)	8.4	8.3
GDP per capita (USD/year)	354	1413
Agriculture value added (% GDP)	46	26
Industry value added (% GDP)	22	34
Service value added (% GDP)	32	40

Source: World Bank country data profile

Table 3.2: Balance of trade (2000 – 2005) in million US dollars

Item	2000	2001	2002	2003	2004	2005
Total Exports	1,807	1,699	1,949	2,543	3,778	4,824
Petroleum	1,351	1,377	1,511	2,048	3,100	4,187
Non petroleum	456	332	438	494	677	637
Agricultural	239	182	179	220	338	333
% agricultural out of non-petroleum exports	52%	55%	41%	45%	50%	52%
% agricultural out of total exports	13%	11%	9%	9%	9%	7%
Total Imports	1,368	2,025	2,179	2,536	3,587	5,947
Agricultural	359	326	468	442	872	854
Non agricultural	1,009	1,699	1,711	2,094	2,715	5,093
Balance of trade	439	-326	-230	7	191	-1123

Source: Bank of Sudan (2006)

3.2 AGRICULTURAL DEVELOPMENT AND FOOD SECURITY

3.2.1 Main farming systems

There are three main farming systems in Sudan namely the peasant irrigated farming, the semi-mechanized and the peasant rain-fed farming systems. The total cropped area in the country is about 18 million ha today of which 9 million ha are cultivated by small scale farmers under rain-fed condition. The irrigated area amounts to 10% of the total cropped area. Irrigated farming produces 100% of cotton, 70% of vegetables, 80% of wheat and 15% of sorghum.

The Rain-fed peasant Farming: The peasant rain-fed farming system exists in Kordofan, Darfur, Sennar, and the Blue and White Nile areas. The total cropped area in this system is estimated at 9 million hectares, with small farmers typically having 10 to 15 feddans (4.2 to 6.3 hectares). In addition to the staple food crops (sorghum and millet), the system is also largely involved in the production of oil seeds (sesame (15 percent), groundnuts (25 percent). Some farmers have recently stated to integrate livestock in their production plans. The peasant rain-fed agriculture in Sudan supports the bulk of the rural poor, estimated at 70 percent.

The Rain-fed Semi- Mechanized Farming: This system covers about 6 million hectares in rainfall areas ranging between 400-800 mm annually in Gedaref, Blue Nile, White Nile, Sennar and Southern Kordofan (Nuba Mountains) areas. Land preparation, seeding and most threshing on these farms are mechanized, while weeding and harvesting are done by seasonal labour. This system produces sorghum, sesame, sunflower and little of short stable cotton. Livestock is not integrated in this farming system.

The peasant Irrigated Farming: It consists of the Gezira irrigation scheme which started operation in the 1920's and other large public irrigation schemes constructed in the 1960's and 1970's such as for example the Rahad, El Suki, New Halfa irrigation schemes and the Managil extension of the Gezira scheme. The cumulated area of the public schemes with small holder farmers is approx 1.7 million ha. Main crops grown by this sector are sorghum, cotton, wheat, groundnut and vegetables. All the public schemes were developed based on the model of the Gezira scheme with the Ministry of Water and Irrigation in charge of O&M and tenant farmers cultivating typical farms of 15 to 20 feddans (6.3 to 8.4 ha).

Most tenant farmers and farm labourers in public irrigation schemes own cattle, especially small ruminants. Livestock, although less important than crops, are a supplementary source of income, which is used to hire labour for agricultural work before the harvest.

Animals depend heavily on crop residues, industrial by-products and the grazing of limited areas of fallow and the sides of canals. Intensive cow's milk production is becoming more common within the large irrigation schemes, and these areas are seen as promising for future expansion of livestock production. Cattle are not used for land preparation. 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.

Commercial irrigated farming: It is represented by the public Kenana and New Halfa sugar estates and recently developed private irrigated farms. This sector covers approx 200,000 ha and grows sugar cane, wheat, sunflower, vegetables and fruit crops. Livestock is not integrated in this system.

Livestock production systems : Sudan has the highest number of livestock amongst African countries. The livestock sector is composed mainly of cattle, goats, sheep and camels that contribute to live animal exports, meat, hides and skins and dairy products for domestic and export markets. The spatial distribution of livestock throughout the country is largely associated with climate variability and presence of natural pastures. In general, the distribution of animals is as follows: Eastern Sudan (mainly camels); Central Sudan (cattle concentrated in the savannas); Western Sudan (sheep and cattle); Southern Sudan (mainly cattle and goats).

In the northern part of the country, camels and sheep, with some goats, are raised by nomadic herders on natural rangelands. Households move with their animals and have no permanent base on which to grow crops. They spend the rainy season in the northern, semi-desert zone and during the dry season, move further south into the savannah. Income is derived from the sale of animals, meat and milk in the form of white cheese. The transhumant agro-pastoral system is located in the Western, Central and Eastern states. In this system, households depend mainly on livestock, mostly cattle, with some sheep and goats, although there is some cropping. In western Sudan, households migrate north during the rainy season and return south to the savannah during the dry season. In the central and eastern states, migration is towards the Nile during the rainy season and back during the dry season. An agro-pastoral system is found in Southern Sudan, where livestock are raised in traditional rain-fed agricultural systems in settled villages. Livestock are moved away from the White Nile in the period of flooding and back when the floods recede.

3.2.2 Performance of agriculture

The performance of the crop harvested area and crop yields constituted the two main determinants of agricultural production growth in Sudan.
As with respect to the crop area, it was observed that despite the general rapid increase in cropped area, harvested area has fluctuated sharply in the three farming system due to climate change, poor maintenance of the irrigation canals, and instability in macroeconomic and sector related policies. As with respect to the crop yields, it was observed that despite the breeding improvements made in sorghum and wheat varieties, their yields are low and unstable. For other crops including millet, cotton and groundnut, their yields even declined in the nineties. The declines in yields in rain-fed farming systems are related to reduction in soil fertility because of short fallow periods and poor soil conservation practices, and use of traditional technology because of lack of credit, particularly for smallholders.

The irrigation sub-sector covers only approx 10% of cultivated areas but contributes for more than 25% of agricultural GDP. The rain-fed mechanized farming covers about 6 million ha and contributes to approx 2.5% of agricultural GDP while the peasant rain-fed farming covers approx 9 million ha and contributes to approx 13%. This crudely indicates that the mechanized farming is less productive than the peasant farming. Despite the fact that public investments in the livestock sector have been very limited compared to other sub-sector, livestock production represents almost half of Sudan agricultural GDP. In spite of the great potential of livestock and Sudan's self-sufficiency in meat and other livestock products, several constraints deprive the country from realizing the full potential of this sub-sector.

Table 3.3: Contribution of agricultural GDP by sub-sectors (2000 – 2005)

Sub-sector	2000	2001	2002	2003	2004	2005
Irrigated agriculture	24.8%	29.4%	27.4%	25.0%	27.5%	28.2%
Rain-fed mechanized	6.3%	2.4%	2.8%	4.5%	2.5%	2.6%
Rain-fed peasant farming	15.6%	16.0%	17.6%	15.9%	12.8%	12.8%
Livestock	47.1%	47.6%	45.4%	47.3%	52.5%	48.7%
Forests	6.5%	6.6%	6.5%	6.8%	7.5%	7.7%

Source: adapted from data of the Ministry of Finance and National Economy (2006)

Harvested areas

The general trend shows an increase of cultivated area from 12 million ha for the 1990-95 period to 18 million ha in the period 2000 – 2005. The increase occurred in the rain-fed sector this is reflected by the increase of areas cropped with sorghum, millet and sesame; the later benefited of favourable export opportunities which were mainly addressed by farmers in the semi-mechanized farming system.

There was no significant irrigation development since the end of the 1970's. Harvested area has fluctuated in the rain-fed farming systems because of recurrent droughts resulting in crop failures every four to five years. In the irrigated farming system, harvested area also fluctuates mainly because of difficulties in the maintenance of canals (removal of silt) and variations in water availability for winter crops.

The area of (irrigated) wheat dropped significantly from 268,000 hectares in 1990-1995 down to 126,000 hectares in 2000-2005 due to the liberalization policy that allowed imports of low priced wheat from abroad. Cotton area dropped in the period 1995-2000 and began to shrink again in 2006-2008 to less than 100,000 ha as a consequence of the removal of government's control on cropping patterns in public irrigation schemes. Inefficiencies in the institutional arrangements for processing, and marketing cotton and delays in payment to farmers are reasons often said for lack of farmers' interest in growing cotton.

Table 3.4: Trends in harvested areas for major crops in Sudan from 1990 to 2005 (Average by 5 years periods in ha x 1,000)

Periods	1990 - 1995	1995-2000	2000 - 2005
Total harvested area	12,200	13,660	18,200
Sorghum	3,902	4,620	4,853
Millet	1,540	2,253	2,165
Wheat	268	180	126
Cotton	240	178	186
Sesame	979	1,749	1,764

Source: Computed from FAO STAT

Yields

Crop yields in Sudan have remained low and unstable over the period 1990 – 2005 with the exception of sesame which is mainly grown in the semi-mechanized farming system. Agriculture production growth can then be attributed to expansion of cultivated areas only. In the rain-fed sector, poor soil fertility management practices (shifting agriculture with short fallow periods), absence of formal institution for seasonal credit and recurrent droughts preventing farmers to invest in improved technology packages are the main reasons put forward to explain the poor productivity.

In public irrigation schemes, 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. 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.

Table 3.5: Average yields of major crops in Sudan (Quintal / ha)

Crop	1990-95	1995-2000	2000 - 2005
Sorghum (rain-fed)	6.1	5.7	6.4
Sesame (rain-fed)	4.2	7.6	7.0
Wheat (irrigated)	16.4	18.7	24.2
Cotton (irrigated)	13.1	11.6	14.4

Source: Ministry of Agriculture of Sudan**.**

Livestock production

In 2005, Sudan produced 350,000 tons of cattle meat and 5.5 million tons of cow milk making the country self sufficient for these products; Sudan exports live animals and meat mainly to the Arab Gulf countries. The number of livestock heads given in the table below is approximate since there is no regular census of the livestock population in Sudan.

Table 3.6: Livestock in Sudan (number of heads)

Type	1991 – 1995	1996 -2000	2001 -2005
Cattle	25.1	34.4	39.5
Sheep	27.7	42.1	48.5
Goat	23.5	36.7	41.6
Camel	2.8	3.0	3.5

Source: Ministry of Animal Resources & Fisheries - Sudan

The following constraints on production are important:

- Overgrazing in some areas, particularly around settlements, while vast areas are under-grazed because of lack of water for the animals;
- The great distances that animals often have to walk from water points to graze;
- Expansion of agriculture, particularly mechanised farming, into traditional grazing land, which has led to reduction in grazing areas and in many instances to the blocking of traditional migration routes and water points, causing conflicts between transhumant and settled farmers;
- Seasonal nutritional deficiencies;
- Prevalence of disease leading to early culling of cattle;
- Poor veterinary services and poor husbandry;
- Poor integration of livestock in the rotation of arable crops including quasi absence of fodder in the rotation;
- Difficulty of marketing and processing milk due to the remoteness of grazing areas far from the centres of consumption;
- Lack of services and infrastructure such as research, extension, roads, health services and livestock markets.

Food security

Sudan is increasingly dependant on imports for wheat. Wheat is becoming the main staple food of the Sudanese population while wheat sown areas have decreased over the last 15 years. In Sudan, wheat can be grown only in winter under irrigation in the River Nile State and the Northern State where the winter is relatively cold. Wheat imports represent more than 50% of the country consumption. Other major food imports of Sudan are sugar and vegetable oil although the country exports sesame seeds.

The economic performance of the period 1996-2007 portrayed the ability of the country to ensure food security and improve economic health at the macro-economic level. The economy achieved a high growth rate of 7 percent of GDP, allowing Sudan to purchase its food needs on the international market. The inflation rate dropped from more than 130 percent in 1996 to 4.8 percent in 2001 and continued on same level.

Table 3.7: Main agricultural imports and exports of Sudan

	Value ('000 dollars)	Volume (tons)
Imports		
Wheat	286 895	1 116 328
Sugar	153 777	267 954
Vegetable oil	119 000	149 454
Exports		
Sesame seeds	86 834	105 464
Live animals	45 840	n.a
Cotton	34 409	22 699
Fruit and vegetables	10 629	n.a
Meat	4 941	2 630

Source FAO STAT (2007)

Till now there are no official data or information on national poverty situation and vulnerability indices in Sudan. The studies on poverty and food security are deficient. Regarding poverty alleviation the government strategy is to develop the traditional farming system because it is the only mean for increasing income of the small producers and households of the rural community.

3.3 AGRICULTURE AND WATER POLICIES

3.3.1 Government Agricultural Policies and Plans

The Sudan Agricultural Green Mobilization Program (GM) for the period 2007-2010 is the guiding framework for agricultural and rural development sector. It was announced in July 2006 by the President of Sudan.

Objectives

The Green Mobilization Program, also referred as the Agriculture Revitalization Program, aims at achieving sustainable and balanced economic and social development to reduce poverty and achieve the welfare of the people of Sudan through the development of the country's huge natural resources (except those of Southern Sudan which is not included in the Green Mobilization program).

The specific objectives of the Green Mobilization Program are the following:

- Achieving food security;
- Reducing poverty by 50% by the end of 2010, provide employment opportunities and increase individual income;
- Achieving balanced development for all the regions of the Sudan to encourage stability in the rural areas;
- Development and protection of the natural resources for sustainable production;
- Increasing and diversifying agricultural exports of plants and animals;
- Maximizing value added in the agriculture at the production stage and in the backward (inputs) and forward (marketing) economic chains.

Since 2005, the government has removed all governmental control on cropping patterns adopted by farmers. However, the government pays a particular attention to the production of cotton, a major export crop, in irrigation schemes and to wheat production for food security. An indirect form of governmental control on cropping patterns may be exercised through attaching credit provision to government-recommended technology packages.

Strategic priorities for agriculture development

Increasing productivity in the rain-fed sector

The small farmers in the rain-fed sector constitute the majority of producers in the agricultural sector and suffer from having access to agricultural services and inputs. The strategy consists in establishing extension centres in each village and improving access of small farmers to good seeds, fertilizers and credit when and where needed combined with investments in rain water management infrastructures.

Increasing Wheat production

High priority is given to increasing the production of wheat since it is becoming the main staple crop for the people of Sudan particularly in urban areas. Sudan does not want to risk dependence of its food security on the increasingly unpredictable international market and especially in case of sudden drop of oil prices.

This concern is shared by many other countries who want to cope with the problem of rising food prices and the world financial crisis. Saudi Arabia, the Arab Emirates, Libya, Japan, China, India, South Korea and Egypt are among these countries. Sudan has devised an incentive policy to attract either national or foreign investors to grow wheat in Sudan. Wheat is the main crop using available water in winter. Wheat production potential is located in the Main Nile valley, where the weather is more favourable for wheat production due to relatively cold winters. The expansion of wheat production is planned to take place in this region and to depend on surplus water from the Nile, and from tapping the Nubian aquifer

Unleashing the potential of livestock production

Strategic intervention in the livestock sector is considered of strategic importance for agriculture growth and increase of export earnings. Interventions for raising the productivity of the sector include:

- Rehabilitation of the natural pastures through collection and spreading of seeds of appropriate fodder plants.
- Improvement in the management of pasture lands by harvesting the natural pastures during the rainy season and storing it for feed during the summer months, reducing overgrazing and conflicts between farmers and pastoralists, opening of new stock routes.
- Introduction of feed crops in the rotation of irrigation schemes.
- Expansion of extension and veterinary services.
- Increasing the number of drinking water points along the routes of the pastoralists.
- Improving livestock market and market information services.

Irrigation expansion

The driver of irrigation expansion is the rainfall variability affecting the rain-fed sector, growing concerns about dependency on wheat import and irrigated fodder production. Required water for irrigation expansion will come from the full utilization of Sudan's share of the 1959 bi-lateral agreement with Egypt, the water savings expected from the modernization of existing irrigation schemes or reallocation of water from the non-functioning schemes and from the development of groundwater namely the Nubian aquifer.

Commercial farming

Development of commercial farming is considered as a major strategic option for agriculture growth. Main projects involve foreign investors, namely from South Korea (690,000 ha for wheat), the United Arab Emirates (378,000 ha for wheat, maize and feed crops), Saudi Arabia (10,000 ha for wheat and vegetables); these projects are at various stages of implementation. In May 2008, The Egyptian government has announced that Egypt is to partner with Sudan to develop up to two million feddan (840,000 ha) to grow wheat in an area close to the border town of Wadi Halfa; this project also envisages to raise livestock. Most if not all commercial farming projects require irrigation.

3.3.2 Development Objectives for Irrigation

The overall objective of the irrigation sector policy is "to develop the huge irrigated agriculture 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." Sudan's irrigation policy has adopted a two-pronged approach: centralization as irrigation development should be fully integrated with the overall framework of the country's socio-economic development plans and decentralization through the promotion of the participation of Water Users Associations in all phases of the policies, planning studies, implementation and operation & maintenance of all irrigation schemes.

3.3.2.1 Irrigation expansion

Sudan wants to fully use its share of the Nile water concluded by the 1959 bi- lateral Agreement with Egypt. It is estimated that out of the 18.5 BCM allocated to Sudan, 4 BCM are currently unutilized, (Country Strategy on Irrigated Water Resources Managemnt, Ministry of Irrigation and Water Resoureces, Feb 2007). The plan for public investments in irrigation expansion includes:

- Implementation of new dams (i.e. the Setit dam) and heightening of the Roseires dam to achieve horizontal and vertical expansion of irrigated agriculture.
- Implementation of new irrigation schemes, such as Upper Atbara, Rahad phase 2 and Great Kenana on the Blue Nile, Aweel rice on the White Nile and Merowe on the main Nile.
- Increase utilization of pumps to expand production of winter crops, mainly wheat along the Main Nile.

Further investments in irrigation expansion would be made feasible from reallocation of the water previously allocated to the non-operational irrigation schemes of the White Nile and Blue Nile Pump schemes, and from saved water resulting of improved irrigation efficiency of operational schemes. Sudan will also invest in groundwater development for irrigation. In the Northern State and the River Nile State irrigation expansion is conceived through supply of water from the Nubian Aquifer.

For private sector investments in the irrigation sector, the policy aims at allocating land on nominal rent to foreign or national private sector companies for long period of 50 to 99 years, at incentive rates varying from one place to another within the state and among states and the exemption of all taxes including profit taxes. Foreign or national investors are also exempted for all imported assets and agricultural inputs from customs tariffs, with designated quantities and quality being decided in the feasibility study of the investment project evaluated and approved by the Department of Agricultural Investment of the Ministry of Agriculture and Forestry. The allocation of land is made after the government ensures absence of land dispute, and when there is dispute based on usufruct practices, the investor is requested to reclaim 25 percent of the allotted land with provision of irrigation water services to the owners of the land. Such arrangements usually take place in irrigated areas of the central states such as those of the Gezira, the White Nile, the Blue Nile and Sennar. In the Northern State and the River Nile State, the land allotment takes place with no dispute since these lands are government lands. Investors do not have to pay for water; however, they have to construct the pumping station site and the irrigation systems. Foreign direct investments have the highest share of the distributed land.

3.3.2.2 Rehabilitation & modernization of irrigation schemes

The policy focus on the adoption of modern technologies in all aspects of irrigated farming for increasing water use productivity and efficiency. This includes (i) modernization/ rehabilitation of hardware in irrigation canals for better control and monitoring of water, (ii) land levelling, and (iii) adoption of modern agricultural practices such as precision farming. So far most of the rehabilitation work consisted in silt removal of irrigation canals.

It is envisaged to group the pump-fed irrigation schemes on the White Nile upstream of Jebel Awlia dam, the Blue Nile near Sennar and the main Nile in the North together with electrification of pumping stations. These groups of schemes will be managed by the private sector. Kenana Sugar Company, one of the world largest integrated sugar companies will take over Rahad and New Halfa irrigation schemes for all aspects of production including entering contract farming agreements with small scale farmers. Kenana Sugar Company, in a profit-sharing scheme with farmers, will improve irrigation and farming technology and introduce new crops including fodder.

It is expected that the output will increase dramatically. Kenana will take 40 percent of profits, with 50 percent going to the farmers and 10 percent towards social investments such as building hospitals and schools. Kenana is part-owned by the governments of Sudan and Saudi Arabia and the Kuwait Investment Authority, hence it is not properly said a private sector firm.

3.3.2.3 Rain water management

The policy seeks a better utilization of the rain water through:

- Constructing small dams across seasonal streams *"wadies"* for use as supplementary irrigation and drinking for livestock in the grazing areas. It is estimated that not less than one hundred million cubic meters of water will be harvested annually in each state by building dams in the Wadies.
- Digging of water harvesting ponds *"hafeer"* for livestock along the stock routes.

A water harvesting program has started in 2008.

3.3.3 Sudanese Water Resources Management

The goal of Sudan's Policy on integrated Water Resources Management is to "lay the foundation for a rational and efficient framework to sustain the water needs of national economic development, poverty alleviation, peace, environmental protection and social well being of the people through sustainable water resources management"

The general objectives of the policy are:

- Equitable, sustainable, economically viable and efficient water management and water utilization based on strategic planning. The strategic planning shall recognize (i) the linkages between water resources development and utilization with the economic development framework at federal and states level of government and (ii) that water resources development, utilization and conservation go hand in hand and by ensuring that all water-related activities such as water supply and sanitation, irrigation and drainage, watershed management are addressed in unison.
- Equitable management and utilization objective relates to the distribution of water between the different States and users and the promotion of national unity through balanced utilization of the water resources and due consideration to poverty alleviation and food security.
- Economic objectives relate to increase of investments in essential water infrastructure and the establishment of financing mechanisms for the management functions.
- Sustainability objectives relate to the preservation of the environment and "disaster management" (flood and droughts) through appropriate water management practices and essential infrastructure development.
- Efficient management objectives relate to the development and capacity building of human resources, the promotion of water users organizations and the private sector for water services.

Main supporting strategies are:

- Set up mechanisms for continuous assessment of surface and groundwater resources availability and quality, monitoring and dissemination of water data using modern and efficient technology;
- Prepare strategies and plans based on the concept of integrated water resources management;
- Enhance cooperation between the States;

- Develop economic criteria for balancing costs and socio-economic benefits of water utilization;
- Empowerment of water users groups and promotion of stakeholders participation;
- Control pollution of ground water and surface waters;
- Strengthen water conservation measures to enhance water availability for environmental purposes and for pastoralists and rain-fed agriculture (water harvesting);
- Address the problem of sedimentation in dams and irrigation structures;
- Enlargement of existing reservoirs (i.e. Roseires) and construction of new dams on the Nile, the Atbara sub-basin and on seasonal streams (wadis).
- Sector main programs include:
- Digging of boreholes and wells for rural drinking water supply in rural areas with objective to reach the minimum 20 l/ capita / day in rural areas;
- Construction of hafirs (water harvesting ponds for animals drinking water) along the routes of the pastoralists and for settlement of nomads;
- Carry-out feasibility studies on hydropower potential development and implement viable new hydropower projects;
- Implementation of new irrigation schemes (Upper Atbara, Great Kenana, Rahad phase 2, Aweel rice, regrouping and extension of the White Nile Pump-fed schemes) ;
- Harvesting wadi water for supplemental irrigation in rain-fed agriculture.

4. DESCRIPTION OF THE PROJECT AREA

4.1 LOCATION AND NATURAL RESOURCES

4.1.1 Location

Wad Meskin Project is located at the Eastern bank of Rahad River. The Project starts at the South of Wad Meskin Village where the proposed Rahad barrage will be located and extends up the Southern boundary of Hawata Town. The northern boundary is limited by the railway line between Hawata and Gadarif the capital of Gadarif State. The project net cultivable area lies between Hawata Town upwards Wad Meskin Village. The study area lies South of the railway line, and east of Hawata town. It covers an area of about 9,600 ha. This is located between latitudes 1,472,500- 1,478,000 m and longitudes 678,000-695,000 m in zone 36P- WGS-84. It extends Southeast from the railway to Ingammena The project area is surounded by a number of towns mainly Hawata which lies at the northern part and tangential to the project, Faw the H/Q of Rahad I project is in the north at 70 km, Dinder Town is located at Dinder River Left bank and about 50 km, Singa Town the Capital of Sennar State is located at the Western bank of the Blue Nile and as far as 100 km from Hawata, the same applies to Sennar Town.

4.1.2 Access

The cultivated area can be reached though many access roads which are available at the region. The road form Khartoum to Port Sudan passes through Faw Town the H/Q of Rahad I Agricultural Scheme, there is an access road form Faw up to Hawata, it is a gravel road that can be used to service the Wad Meskin Project all the year around, the rough road from Hawata Town to Wad Meskin Village which is about 70 km long, it is accessible in the non rainy seasons. One road from Sennar Town at Blue Nile bank is extended to Hawata through Sukki and Dinder Towns it is a gravel road in most of its length and this is accessible in the non rainy seasons. The third road is through Singa Town which is the capital of Sennar State, it starts at Singa Town up to Dinder Town, the road is asphalt paved road up to Dinder Town and the balance is a gravel road. All above roads are originated from Khartoum to the project area and also linked to Port Sudan the national port of Sudan.

The project is connected to Port Sudan the Main sea port via Al Faw and Gadarif Town. Tthe length of the gravel road to AL Faw the H/Q of Rahad I Agricultural scheme is 70 km, from Al Faw to Gadarif through a paved road of 150 Km and from Gadarif to Portsudan about 777 km. Singa the capital of Sennar state is located to the east of the project area at the Western bank of the Blue Nile it is connected to Hawata through a rural road of 90 km length, from Singa to Khrtoum through Sennar and Wadmedani a paved road of 367 km. The railway line passes from Khartoum and the Western Sudan through Hawata to Port Sudan but it is not operating since more than twenty years, the system is under an rehabilitation program now. The railway line is extended from Port Sudan to Khartoum and passed through Hawata Town although is idle for the time being but it is planned to be rehabilitated in the very near future. A complete new railway infrastructure would be required. The future plans are available to build the road from Sennar to Hawata Town and make it an asphalt road also a plan is to extend the Singa-Dinder road to Hawata Town.

The road from Faw to Hawata lies within Rahad I project also part of it was paved but deteriorated being left without maintenance but is planned as per the Rahad I rehabilitation program is to be maintained and reconstructed. The main structures available at the region are the Sennar Dam, Singa Bridge which are located across the Blue Nile, and the Dinder and Rahad railway bridges which are located at Dinder Town and Hawata Town respectively. An electrical power line is installed form Singa to Gadarif though Hawata and intended to serve the area.

4.1.3 Soils and Land Suitability

The soils, the land suitability and the land use of a 9600 ha area south of the railway line and east of Hawata town is located between latitudes 1472500-1478000 m and longitudes 678000-695000 m in zone 36P- WGS-84. It is based primarily on the Land and Water Research Centre soil survey report of the area (LWRC, 2009). The area falls within the semi-arid climatic zone where the average annual rainfall is 581 mm and the mean annual temperature is 28.7°C. The soils were developed on the Blue Nile and its tributaries alluvial deposits being transported from the Ethiopian Plateau. The indigenous vegetation consists mainly of *Acacia seyal* (talh), *Acacia mellifera* (kitr) and *Balanites aegyptiaca* (heglig) with thick grass understory. The existing land uses are rainfed and pump irrigated agriculture in addition to grazing. According to the U.S. Soil Taxonomy, the recognized soil mapping units in the area belong mainly to the Vertisols Usterts suborder i.e. Vertisols with an Ustic soil moisture regime. The land suitability evaluation has shown that at current conditions 72 % of the soils of the area (6912 ha) are rated as Class S2 (moderately suitable land for irrigated agriculture), 27.1 % (2603 ha) are rated as Class S3 (marginally suitable for irrigated agriculture). These can be made more productive and their suitability class upgraded if land amelioration measures, including land levelling, soil drainage and fertilizer application are adopted.

The remaining 0.9 % of the soils of the area (85 ha) are rated as Class N2 (permanently unsuitable land for irrigated agriculture).

The main current soil constraints to agricultural production in the area consist of:

- Vertisolic (v) or high clay content which retards water movement through the soil and also creates poor soil aeration conditions.
- Moderate chemical fertility (f)
- Hazard of inundation (i) in parts of the area close to the River
- Topography (t) at the low lying and depression sites

If certain measures are adopted including, proper levelling, good drainage system, use of farm machinery at optimum soil moisture, addition of nitrogen and phosphorous fertilizers the expected potential land suitability class of the bulk of the area soils will be upgraded to the moderately suitable land Class S2 with only one inherent constraint i.e. the vertisolic limitation (v) due to the high content of swelling clay. The table below summarizes the area current and potential land suitability classes and subclasses. The table also gives the recommendations for each soil unit for agricultural development based on the land suitability classification and the suggested remedies for land management.

Table 4.1: Summary of soil characteristics

Map unit	Current land suitability classes and subclasses	Potential land suitability classes and subclasses	Area (ha)	% of total area	Recommendations for development based on land suitability classification
VT(10)	S2vf	S2v	6,624	69 %	Recommended
VC (20)	S2vf	S2v	288	3 %	Recommended
VTd (30)	S3wvf	S3v	2,315	24.1%	Recommended for tidy rice production
VTg (40)	S3tvf	S3v	288	3 %	Recommended
D (50)	N2	N2	85	0.9 %	Not recommended
Total			9,600	100 %	

Finally, the land use is defined as gravity irrigated agriculture based on the physical, economic and social factors prevailing in the area. The land utilization types are defined. The importance of soil and water managements is stressed for sustainable land uses. This entails need to adopt certain measures in the area including, proper levelling, efficient drainage system, crop rotation and adoption of recommended cultural practices.

4.1.4 Climate

Sudan climate ranges from arid in the north to tropical wet-and-dry in the far southwest. Temperatures do not vary greatly with the season at any location; the most significant climatic variables are rainfall and the length of the dry season. Variations in the length of the dry season depend on which of two air flows predominates, dry northeasterly winds from the Arabian Peninsula or moist southwesterly winds from the Congo River basin.

From January to March, the country is under the influence of the dry northeasterlies. There is practically no rainfall countrywide except for a small area in northwestern Sudan in where the winds have passed over the Mediterranean bringing occasional light rains. By early April, the moist southwesterlies have reached southern Sudan, bringing heavy rains and thunderstorms. By July the moist air has reached Khartoum, and in August it extends to its usual northern limits around Abu Hamad, although in some years the humid air may even reach the Egyptian border.

The flow becomes weaker as it spreads north. In September the dry northeasterlies begin to strengthen and to push south and by the end of December they cover the entire country. Yambio, close to the border with Zaire, has a nine-month rainy season (April-December) and receives an average of 1,142 mm of rain each year; Khartoum has a three-month rainy season (July-September) with an annual average rainfall of 161 mm; Atbarah receives showers in August that produce an annual average of only 74 mm.

The haboob, a violent dust storm, can occur in central Sudan when the moist southwesterly flow first arrives (May through July). The moist, unstable air forms thunderstorms in the heat of the afternoon. The initial downflow of air from an approaching storm produces a huge yellow wall of sand and clay that can temporarily reduce visibility to zero.

The Blue Nile Region comprises two sub-regions, the Blue Nile River and its two tributaries Dinder and Rahad. The climate within the Blue Nile varies from North to South. The meteorological stations adjacent to the project area are Sennar, Singa,Resoreis and Hawata. Their mean annual rainfall (mm) and mean annual evaporation (mm/day) are shown in Table 4.2. Evaporation data are the Penman values calculated by Sudan meteorological services from basic climate data. Note that the record used is for the period from 1960 to 2000.

Table 4.2: Mean Annual Evaporation Rates in the Blue Nile Region

Station	Mean annual Rainfall (mm)	Mean annual evaporation (mm/day)
Kamlin	247	7.5
Wad Medani	362	7.3
Sennar	472	6.9
Singa	579	6.4
Roseires	647	6.1
Hawata	610	6.3
Abu Naama	572	6.2

Table 4.3: Sennar Normals 1971 – 2000

Month	Max Temp °C	Min Temp °C	Relative Humidity %	Sunshine hrs	Wind speed ms^{-1}
J	33.4	13.2	38	10.4	1.5
F	35.5	14.8	33	10.2	1.5
M	38.8	17.8	26	9.8	1.9
A	41.4	21.2	26	10.1	1.9
M	40.8	24.3	36	9.2	1.9
J	39.0	24.3	47	8.7	2.2
J	35.5	22.6	62	6.8	2.2
A	34.0	22.1	69	7.1	2.2
S	35.3	22.2	65	8.1	1.9
O	37.7	22.0	52	9.3	1.5
N	36.7	17.7	38	10.3	1.5
D	34.0	14.3	40	10.3	1.5

Table 4.4: Wad Medani Normals

Month	Max Temp °C	Min Temp °C	Relative Humidity %	Sunshine hrs	Wind speed ms^{-1}
J	32.9	14.1	34	10.4	2.2
F	34.7	15.9	27	10.2	2.2
M	38.1	18.9	22	10.3	2.2
A	41.2	21.8	21	10.3	1.9
M	41.5	24.6	32	9.8	1.9
J	40.3	25.1	42	9.0	3.1
J	36.6	23.4	59	8.5	3.1
A	35.1	22.6	68	8.1	2.8
S	36.2	22.3	65	8.9	1.9.
O	38.3	22.0	50	9.9	1.2
N	36.7	18.4	36	10.6	1.9
D	33.7	15.4	37	10.4	1.9

Table 4.5: Damazin Normals

Month	Max Temp °C	Min Temp °C	Relative Humidity %	Sunshine hrs	Windspeed ms^{-1}
J	35.2	16.6	30	10.2	1.9
F	36.9	18.3	23	10.4	2.8
M	39.5	21.7	20	9.8	2.2
A	40.6	24.2	25	10.0	1.5
M	38.5	24.8	44	9.3	1.5
J	35.3	22.6	61	7.3	1.5
J	32.1	21.4	74	6.1	1.5
A	31.3	21.0	79	6.1	1.2
S	32.5	20.9	76	7.4	1.0
O	34.9	21.3	67	8.8	1.0
N	36.8	19.0	40	10.0	2.2
D	35.6	16.9	33	10.3	2.5

Annual rainfall and potential evaporation in the region are represented in figures 4.1 and figure 4.2 below.

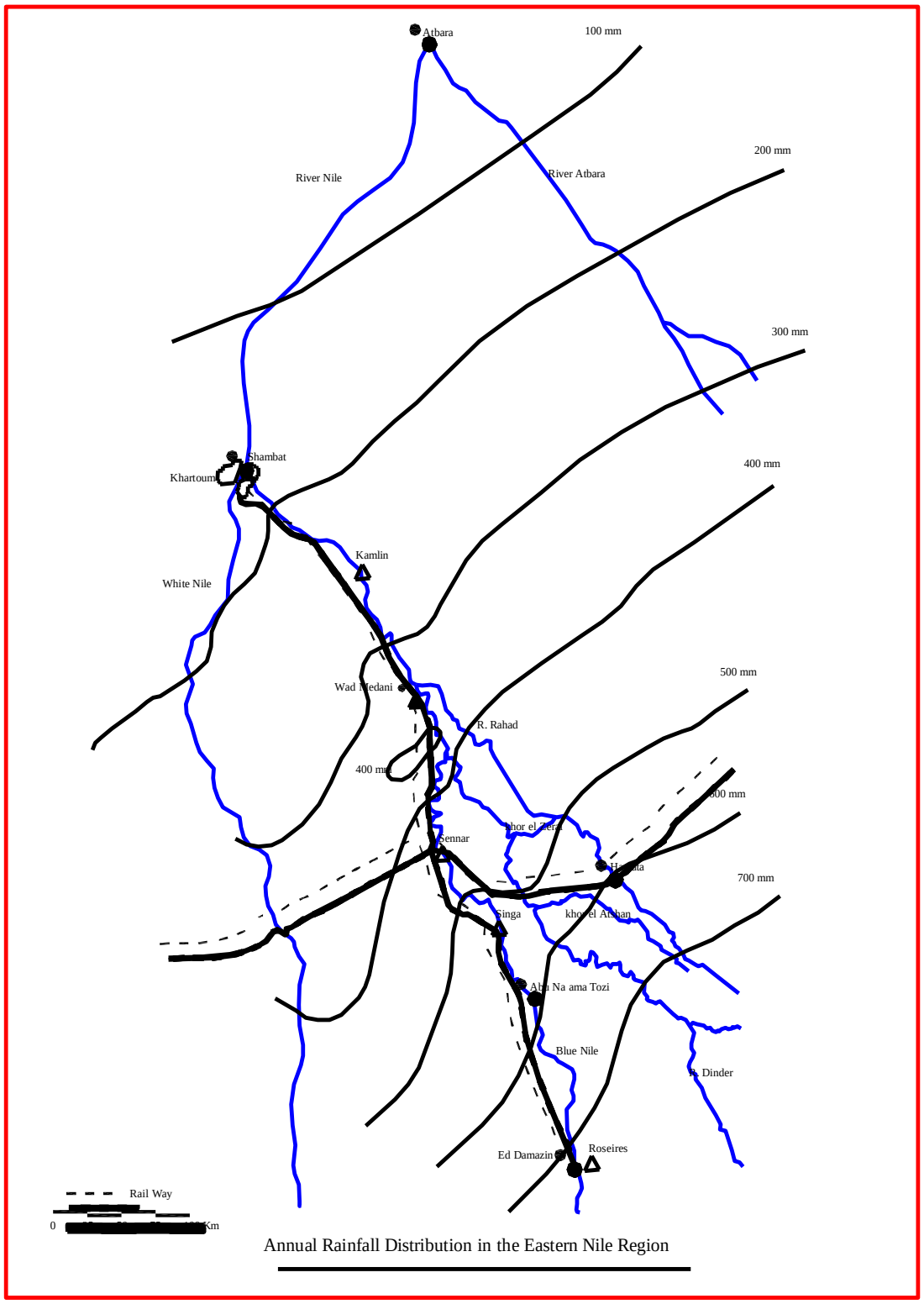


Figure 4.1: Annual Rainfall Distribution in the Blue Nile Region

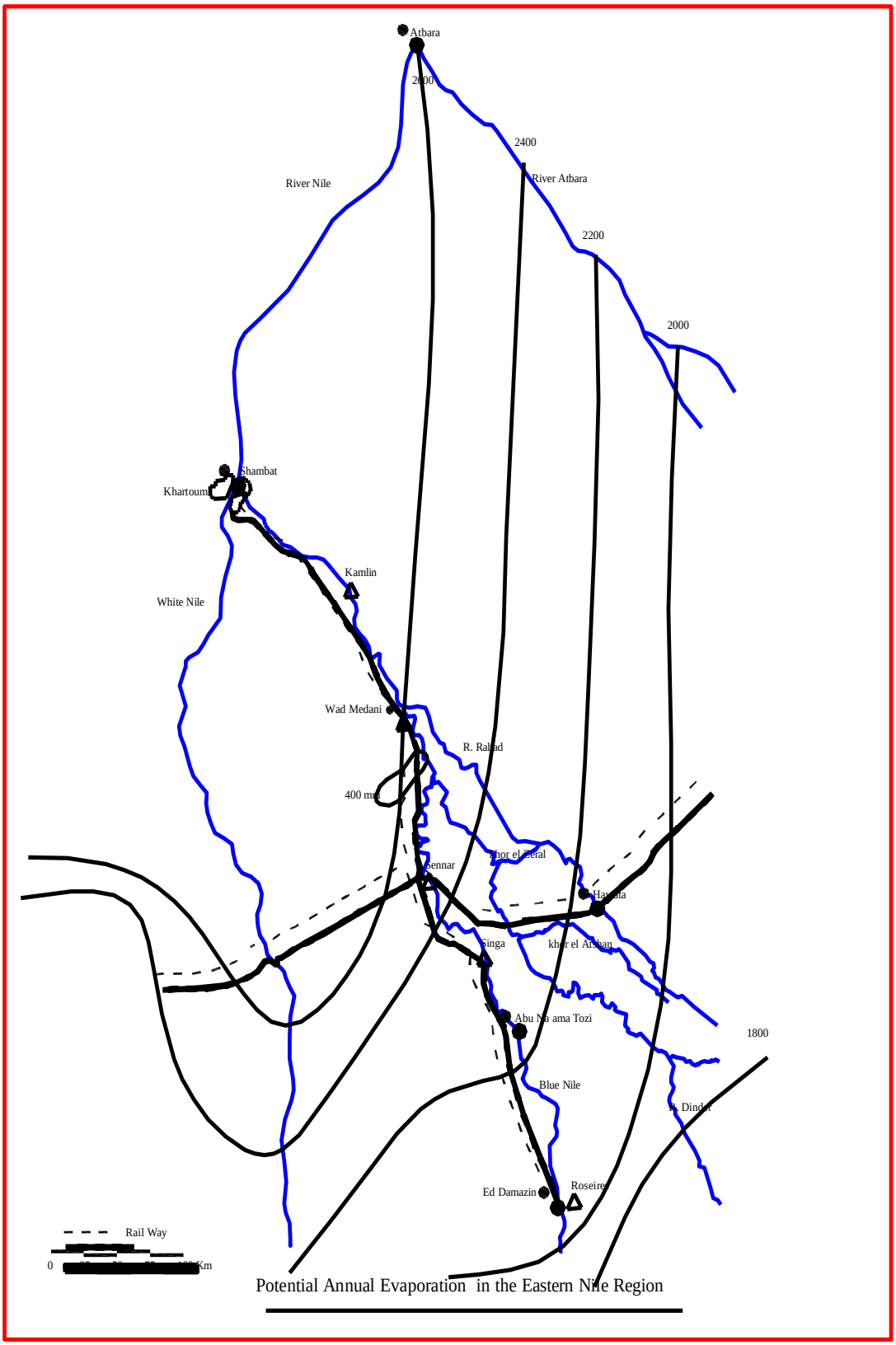


Figure 4.2: Potential Annual Evaporation in the Blue Nile Region

4.1.5 Water Resources

The Blue Nile and its tributaries all raise on the Ethiopian Plateau at an elevation of 2,000 to 3,000 meters above M.S.L. The River has cut a deep gorge through the Ethiopian Plateau, which is in some places 1,200 meters below the terrain level on either side. The Blue Nile emerges from the Plateau close to the Western border of Ethiopia, where it turns north-west and enters the Sudan at an altitude of 490 meters above M.S.L. Just before crossing the frontier, the River enters the clay plain, through which it flows over a distance of about 735 km to Khartoum. At this point, the Blue Nile joins the White Nile to form the main stem of the Nile River.

Two dams have been constructed on the Blue Nile, one at Sennar and one at Roseires, respectively at some 350 and 620 km southeast from Khartoum. The Sennar dam was completed in 1925, with an initial storage capacity of about 0.9 BCM. By now, its live storage has been reduced to about 0.4 BCM, according to a recent bathymetric survey. The dam has been constructed for irrigation of the Gazira scheme. Downstream of the Sudan border two tributaries of some importance join the Blue Nile in the reach between Sennar and Wad Medani, namely the Dinder and Rahad Rivers. They join the Blue Nile 258 km and 189 km respectively upstream Khartoum. Both Rivers originate from the Ethiopian Plateau, about 30 km west of Lake Tana.

The water resources in Hawata area and in the Gadarif State are found in nature either as rain-water, seasonal streams (Wadis and Khors) or as groundwater. Rainfall constitutes the important water component in the state. The rainfall rates are less than 300 mm/y, in the northern parts, and it reaches about 900 mm/y at the east southern parts. The runoff constitutes the Blue Nile tributaries in the locality namely Rahad River, Dinder River and Atshan River. The groundwater within the area under study is occurred mainly in the sedimentary cover which is consisted of the alluvial deposits at the beds and banks of the seasonal Rivers (El Rahad, El Dinder and El Atshan).

Some small amounts are occurred at the fissures and weak zones, Hand dug wells reaching depth of (10-15) m are prevailing along these Rivers. Slum borehole installed with hand pumps are also exist to provide small villages and (Forgans) belonging to nomads. The other option is using of the pools remain within the Rivers beds after stopping of the runoff after the ceasing of rainfall, due to the end of rainy season. The northern part of the locality, at slightly kilometres south Wad El Agilie village begins what is called Atshan Formation aquifer. This is very rich in ground water and extending up to Blue Nile eastern bank. This aquifer is recharged from El Rahad, Dinder River, and Atshan Rivers and directly from rainfall and Blue Nile. The monthly flows for the two rivers are give in the figures

Table 4.6: Annual Maximum Floods for Dinder and Rahad (MCM/day)

Giwasi (1972-98)	Hawata (1972-98)
44.9	13.9
46.8	14.4
60.6	16.5
91.9	16.1
63.8	13.7
54.4	12.8
50.5	15.5
37.6	14.4
52.6	15.8
47.1	17.8
47.1	14.4
41.1	13.7
15.2	7.5
56.9	15.3
30.4	12.7
40.4	14.4
72.1	16.1
51.7	13.6
44.1	12.3
47.3	14.2
45.4	15.7
42.9	14.6
61.4	16.6
32.3	13.3
41.4	12.2
37.9	12.2
44.6	14.9

Table 4.7: Average Monthly Flows for Dinder and Rahad (MCM)

Months	Dinder	Rahad
Jan.	0.00	0.00
Feb.	0.00	0.00
March	0.00	0.00
April	0.00	0.00
May	0.00	0.00
June	206.44	147.39
July	303.00	143.34
Aug.	869.43	340.96
Seb.	960.61	355.36
Oct.	448.21	168.03
Nov.	130.61	16.34
Dec.	8.15	1.29
Total	2926.45	1172.72

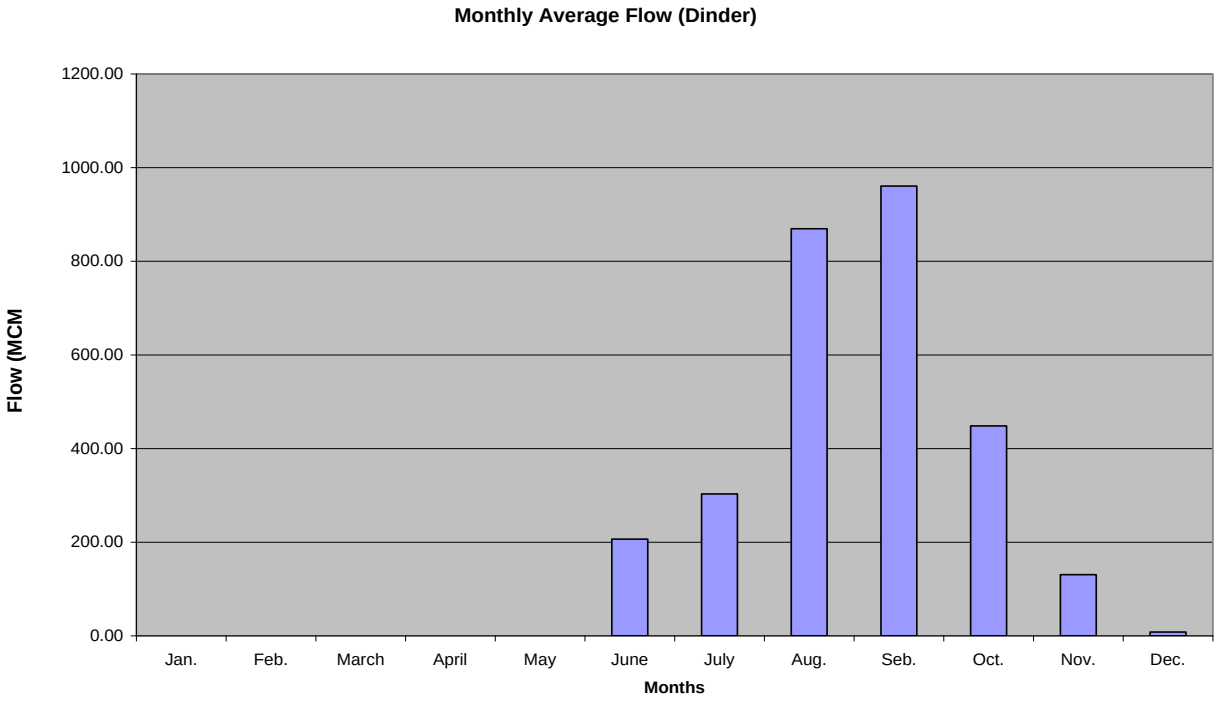


Figure 4.3: Monthly average flow (Dinder)

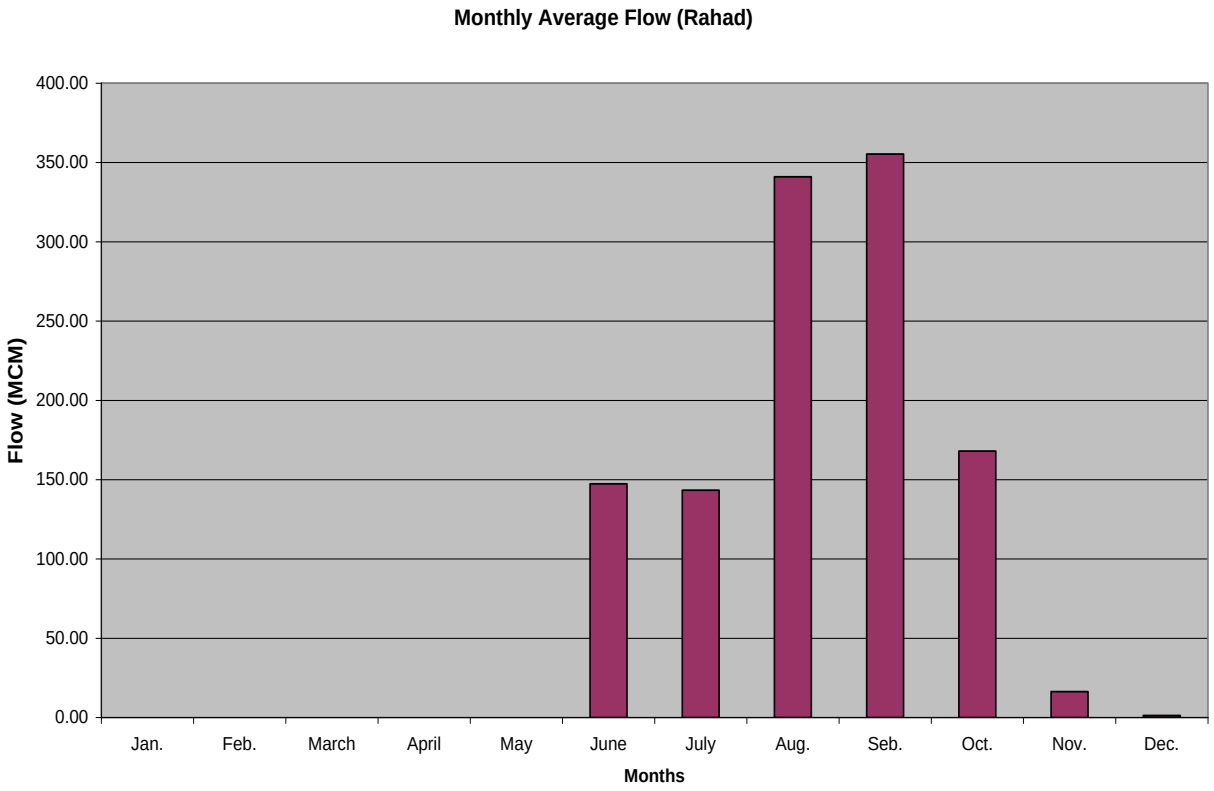


Figure 4.4: Monthly average flow (Rahad)

4.2 THE ECONOMY AND POPULATION

4.2.1 Local Economy and Development Status

The project area local economy depend mainly on the rain fed agriculture , Rahad River flood area plantations, livestock breading activities and forests products like charcoal and Arabic Gum. There a wide range of agricultural products available in the area. The rain fed products are sorghum, maize, sesame, sunflower, peanut an vegetables. The fruits are available especially at the banks of the Rahad River they are mainly mango, lemon, guava and other citrus fruits.The vegetables available at the area are planted at the River bank and irrigated from the flood and some surface water wells all around the year. The vegetables are tomato, onion, cucumber, water melon, maize etc. The local economy of the people living at the River bank depends mainly on the agriculture. Livestock is available at up lands where nomads bread cheap, cattle and camels mainly for breading and marketing it in the near markets, no milk processing is practiced to make use of milk in producing farms.

Due to the availability of forests it is practiced to produce Gum Arabic in the area but is not a standard practice in the region also char coal production is available although ids is and illegal practice which contributed in the deterioration of the forests at the region. The infrastructure available at the region is the railway line which links Khartoum to Port Sudan through Hawata Town and the road network that passes through the region and the power line that crosses the area.

The region has many social services facilities; there are sports and youth facilities available at Hawata Town besides many society clubs which are available. In Hawata Town there is and regional hospital which serves the people around Hawata with small clinics scattered in the main villages of the region to serve the community. Schools and educational facilities are available to serve the region mainly secondary schools at Hawata and primary schools all around the villages.

Power is available at Hawata Town through a local génération plant which is unable to meet the demand of the town. It is shaded during the day but the new power transmission line which is already installed will supply continuous power to the Hawata Town and the near villages in the very near future. Different banks branches are available at Hawata to serve the financial and business sector they provide the necessary finance services for the region which includes financing the agricultural operations, trade operations and the many transfer and savings. Drinking water supply to Hawata is available through a field of water wells located at the Atshan basin and fed to Hawata through a pipeline crossing the Rahad River and the system is extended up to Gala Al Nahal Town which is 50 km East of Hawata also it feed the village around Hawata with clean and health water. Mosques are available in all villages to perform prayers beside some of them offer Quran teaching which is a pre-education schools and practiced in many villages.

Hawata is the capital of Hawata locality and it accommodates the locality head quarter. The locality is a part of the local government regime which is composed of States, localities and administrative units. Hawata locality is subdivided into many administrative units which serve the citizens directly.

4.2.2 Population

The survey in the project area showed that the area is sparsely populated by different tribal groups living in compact villages. The survey covered 10 villages; the largest is inhabited by about 5,000 persons. Lack of services and water supply influenced the growth of these villages. It is observed that most of the villages are located close to the River Rahad to make use of the pools of the River for drinking and to utilize the River banks for cultivation. The area being sparsely populated attracted migrants from West Sudan who settled in the villages along the River Rahad. This created ethically mixed population.

Table 4.8 reveals the village characteristics in which parameters like establishment of the approximate population and the tribes living in the villages are found. Apparently, these villages were established long some time ago. Some of them like Hilat Khalifa have been established during Mahdia era. The recent one is Ingamaina, but also dated back to early seventies. This means that, the people have created a way of life suiting their surrounding environment and typically representing the rural traditional and peasant communities. Nonetheless, there are semi-nomads like Awlaad Saeed tribe in Kumor Basheer. On the other hand, some villages are densely populated like Hilat Khalifa, Bazora Khalifa, Wad Abakar, Maykankana, Abdel Lateef and Kumor Basheer. Concerning the tribes living in the area, it is very rare that a single tribe is dominating the village with only exception in Maykankana in which Hawsa is the sole tribe. All other villages are inhabited by different tribes. In some cases eight or more tribes are found in one village. It is worthwhile to mention that, although these tribes have different ethnical and cultural background, they have developed their own mechanism that helps to promote peace and/or to mitigate conflict among them.

Table 4.8: Village characteristics

Village	Establishment (approximately)	Total population	Main tribe	Other tribes
Bazora Kahlifa	1942	4,000-5,000	Hawsa	Folani
Hilat Khalifa	1885	5,000-6,000	Rofaa	Galeen, Barno, Folani, Abdalab
Ingamaina	1970	400	Masaleet	Taaysha, Bargo, Four
Kumor Basheer	1950	1,400	Hawsa	Awlaad Saeed
Wad Batool Mokharim	1945	400-500	Habaneya/For	Hawsa
Wad Batool Hilat Bakheet	1930	200-300	Hamada	Gawasma, Marareet, Bargo, Maseerya, Tama, Masaleet
Shamam	1950	600	Barno	Awlad Rashid
Wad Abakar	1831	1,500-2,000	Hawsa	Tama, Four, Salaamat, Zagawa, Bani Halba, Dago, Abyadaab
Abdel Lateef	1940	1,500	Bargo	Bagara tribes, Masaleet, Dago, Barno, Four, Folani, Hawsa
Maykankana	1930	1,700	Hawsa	No other tribes

Source: Field Survey July 2009

4.3 Existing Agriculture, Landuse, Forestry and Land Tenure

4.3.1 Crop Production

Generally the whole area of the project is unregistered government land which is subject to the states rights of utilization or lease to potential investors. Due to the adequate rainfall foe crop production in the area, illegal mechanized sorghum and sesame cultivation have been introduced in most of the area of the suggested project.

These farmers grow mainly sorghum and sesame. The normally have holdings that range from 400 to 500 ha. Machinery is used in this agricultural system which permits the cultivation of these comparatively large areas. They normally plough the land used wide level disc harrow after the initial showers to get rid of the weeds and to create a good seed bed. They sow seeds using the same implement or seed drill. Productivity varies according to the amount of rainfall and its distribution. For sorghum productivity is about 0.5 – 1.5 ton/ha while sesame scores 2.5 – 7.5 Kentar/ha. Also the land is marginally utilized by nomadic livestock owners living in the area beside the common production of shifting cultivation by small and most likely poor farmers. Those who normally cultivate small areas, grow mainly sorghum as food crop. They cultivate small areas of 2 – 4 ha per man as they depend on themselves in all the agricultural operations. Usually, production under this system is very low as farmers use the traditional practices and do not apply the recommended practices which include improved seeds, plant populations or fertilizers applications. Under this system yields of 0.24 to 0.7 ton/ha are considered reasonable.

Close to the Rahad River, more intensive crop production that gives better yields is practiced in the form of small fruit gardens in which mangoes, citruses and guava are grown. Winter vegetables are also grown inside the Rahad River basin which when the river flow stops. This system enjoys more fertile soils close to the River which carries silt for the origin in addition to better irrigation (supplementary irrigation) which is possible close to the River. These crops are of high value in the market so they get much more care compared to rainfall field crops.

4.3.2 Livestock production

Settled villagers in the Wad Meskin area keep few livestock. In total there are about 650 cattle, 2,100 sheep and 1,450 goats. These animals provide some milk, a little meat and possibly a small surplus sold for cash.

Table 4.9: Livestock numbers in settled villagers in the Wad Miskeen area

Village	Livestock		
	Cattle	Sheep	Goats
Bazura Khalifa	100	300	80
Hilat Khalifa	300	500	200
Ingamaina	0	0	20
Kumor Basheer	15	150	70
Wad Batool Mokharim	0	80	20
Wad Batool Hilat Bakheet	0	0	10
Shamam	0	200	200
Wad Abakar	150	400	600
Abdel Lateef	10	200	150
Maykankana	75	300	100

Source: Socioeconomic Field Survey July 2009

Pastoral transhumance is the main livestock production system in the project area. It has been said that this system (together with fully nomadic pastoralism as practised in the far north of Sudan) "are ecological adaptations to the rigours of a stern environment". The project area provides one of the most stern environments imaginable. Transhumance is a logical response by livestock owners to the all pervading problem of finding sufficient nourishment for their animals and themselves. A pastoral transhumance system can be defined as one that obtains more than 50 per cent of the total of its household revenue (including the value of home consumption plus income) or more than 20 per cent of human food energy from livestock or livestock products. Earnings from transport by camels and donkeys and from sale of labour in the urban areas also contribute to total income. The major pastoral tribes in the area are Rufa'a, Gawasma, Halloween and Lahoween. There are also small numbers of migrant pastoralists from western Sudan as well as "Sudanized" migrants from West Africa. These last were mostly Fulani in origin but are known as Fellata in Sudan: some have been in Sudan for many generations and their origin, among other things, is attested in some of the cattle of the area.

In the main part of the Project Area water is plentiful during the rainy season ('kharif') but becomes increasingly scarce as the dry season ('seif') progresses[3]. Pastoralists, however, must leave the main part of the project area in the 'kharif' as their presence is a constraint to crop production. In the project area, however, movement is also impelled by the increasing presence of noisome physical presence of sucking and biting flies including members of the family Tabanidae which are vectors of many human and livestock diseases including trypanosomosis.

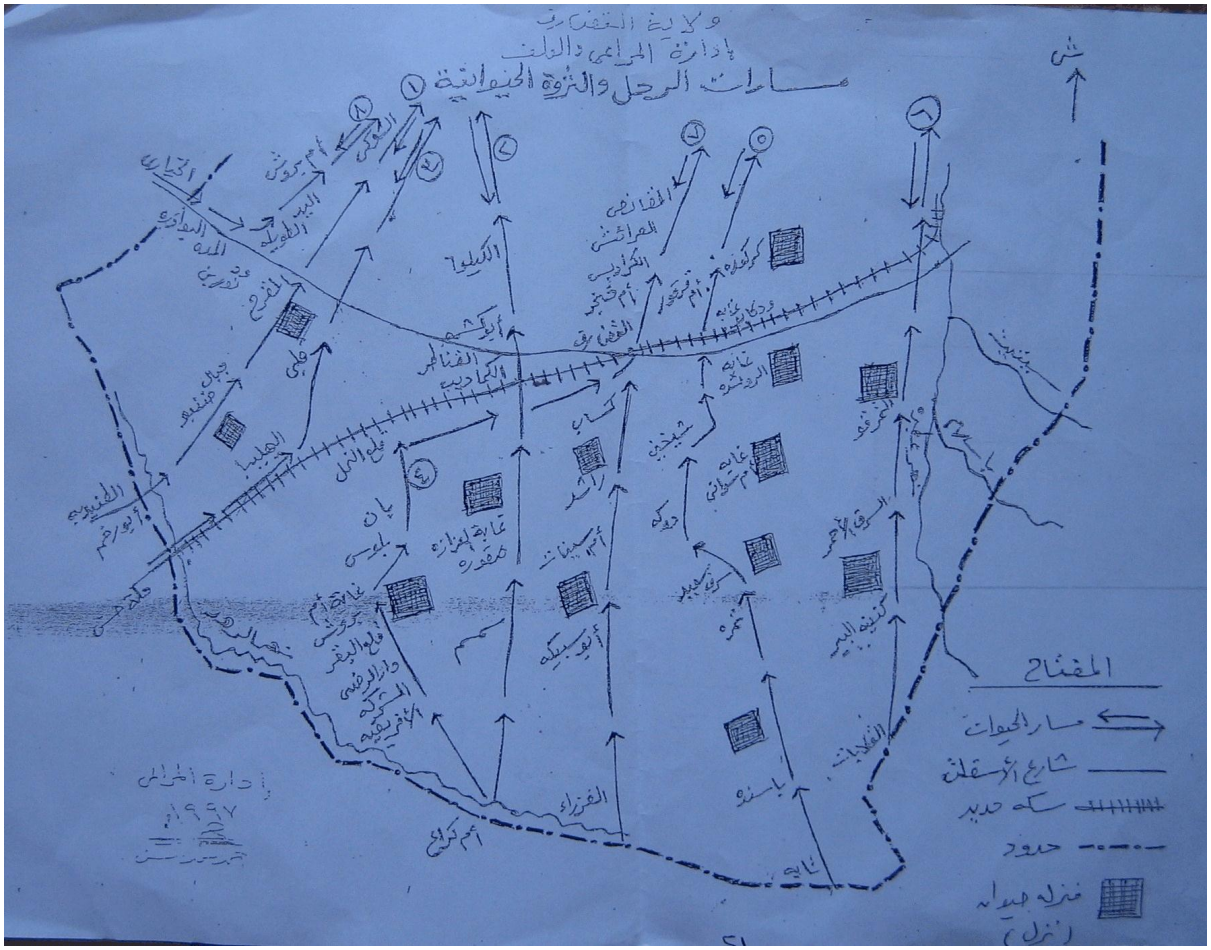
Thus, they move from the south in the early 'kharif' travelling northwards, mainly to the Butana grasslands in July and return southwards in late October when rainfed crops should have been harvested. To facilitate these movements a number of "stock routes" traverse the area (Figure 4.1). These are mainly inclined in a southwest/northeast direction and some take in the district centre of Hawata which is an important location for exchange of goods and marketing of livestock (although every village, almost irrespective of its size, also has facilities for such functions.

Competition for land between cultivators and livestock keepers has intensified in recent years. Although nominally accepted by crop farmers the spread of both subsistence and larger scale semi-mechanized farming has led to encroachment onto and partial or total blocking of the traditional stock routes. The administrative authorities try to minimize the resultant inevitable conflicts between farmer and pastoral groups but these are still very real. Many of the problems also relate to access to water.

Livestock owners must have access to water on a regular basis both at their camps in the dry season and on the stock routes during both their northerly and southerly movements. Animal husbandry ("management") practices, within the limitations imposed by the environment, are generally good by the large scale livestock owners. The annual transhumance is a striking example of an adapted management practice. Owners are also aware of disease problems and take traditional and modern steps to mitigate these often by avoiding places that are known risk areas for disease or by using medicines and vaccination. Many owners are also aware of the value of supplementary feeding: although this is not practised as a general rule because of the expense and difficulty of obtaining concentrates some owners who have created for themselves a niche market in milk production do provide their lactating cows with supplementary feed.

[3] The situation during the 2009 season has become critical following yet another low rainfall year: normally there are up to 25 suitable drinking places in the meander channels and oxbow lakes of the Rahad river but in late November 2009 – with probably eight months of the dry season remaining – there were only three

Figure 4.5: Traditional stock routes through the Project Area



4.3.3 Forestry

The whole project area lies within the rich savannah belt with a dense vegetation cover. The dominant tree species: Acacia seyal **(Taleh)**, Balanites aegyptiaca **(Heglig)**, Acacia mellifera **(Kitir)**, Acacia senegal, Combretum hartmannianum, Anogeissus leiocarpus and Entada sudanica occur together with Boswellia papyrifera specifically in hill slopes and soils formed in sites round the hills. Sunt, Acacia nilotica forests along the banks of River Rahad are an important forest resource for sawn timber. The main Forest activities are sustainable forest management for sawn time productivity namely in the Rahad sunt forests in Hawata Forest Circle , forest protection, seed collection, seedling production, afforestaion and social forestry are the most important forest activities in Gedaref State.
Gedarif State natural forests provide significant contribution to the country supply of fire wood and charcoal mainly derived from Acacia seyal. Social forestry is widely practiced in various localities. An extensive programme of shelterbelts is undertaken annually, in this programme 5% of rainfed mechanized farms (schemes) areas are planted with trees. Forest extension addresses environmental awareness raising through field demonstration of tree planting specifically in the refugee camps as well as energy saving.

4.3.4 Production Constraints and Sustainability of Landuse

The production constraints can be summarized as follows:

- The inhabitants of the area are mainly nomadic tribes that raise livestock and agricultural production is not their main concern;
- Unpredictibility of the rainy season with respect to the amount of precipitation as well as distribution;
- The traditional practices used in crop producer lake capacity building, technology transfer, improved seeds and other inputs e.g. fertilizers.

4.3.5 Land Tenure

Generally land tenure in the area is based on customary regulations or lease given by the Government to an individual for certain number of years. Customary tenure has its origins in the tribal system where the tribal leader is considered the custodian of the tribal land and each individual has the right to be given land for cultivation. Land which is not claimed by any individual is for common use, left for grazing or to be given a migrant by the village head. Land given to any person cannot be taken from him unless he leaves the village.
Land held in such manner is inherited, sold or rented. Migrant are given land by the Sheikh or rent land for cultivation but allowed to use fallow land for grazing. In recent years and with the use of tractors, some rich villagers get lease from the Government for certain number of years and pay fees for licence.

Government land laws give the Government the right to take land for public use and compensate the claimant. The Sudan Interim Constitution of 2005 recognizes the customary tenure and the right for compensation, land for land or cash. Under certain circumstances and as the inhabitants in the area welcome the proposed project, land tenure will not be a problem. Land could be taken for the project and compensate the claimants. Under such circumstances, land settlement committee will be formed to register claims and agree with the local representatives on approaches and mechanisms for compensation.

4.4 MARKETING INFRASTRUCTURE AND SUPPORT SERVICES

4.4.1 Marketing and Agro-processing

In Sudan all farm products, except cotton, are put on sale by liberal decision makers such as (i) the industrial companies and (ii) the network of tradesmen as assemblers, traders, wholesalers, brokers. The latter are the collectors of farm products, and act as an interface for producers. This organisation reveals a lack of decision for farmers. Better market information broadcasted towards them would allow introducing bilateral trade talks. Sometimes industrial firms clinch a deal with cereals producers including purchase contract before the harvest, mostly in the most productive and largest areas. For the future the project area will certainly follow the present scheme unless otherwise agreed between the two parts. The support of outlets is done by industrial big firms as Oil Seeds Company or Safola who treat raw material. Strategic reserves are also organised by Agricultural Bank of Sudan, specifically for cereals with a major attention for wheat. Cereal, pulses and oil seeds are fast-moving items, and producers find by this way an easy occasion to encounter the high industrial demand. The very weak valuation of farm products is the only poor compensation of this choice. The normal course of vegetable selling doesn't use any specific support to reach the final consumers. These kind of perishable goods are sold through the local village markets, without intermediaries' agents. The direct selling is generally supported by men close to their main home, or in a short distance of production area. With the project, the future increase of marketable perishable goods, certainly with important quantity over passing the local household food security needs, will oblige to organise storage system with freeze equipments, and prepare some essential rules to integrate the quality criteria of tradable products.

Generally speaking the farmers lack of facilities to organise the fresh market products and need some technical elements to master storage constraints and supplementary costs, and to protect their crops against the external stresses.

The stockbreeders, as a big majority of farmers in Sudan, suffer of a lack of market information to optimise the value of their stock. The breeders are particularly kept isolated from accurate data and are often constraint to sell cut-prices to avoid a waste solution for milk and meat productions. In their case all modernization system done to insure a well preserved milk state (or meat state) can have an immediate impact on their revenues. Sudan is importing sorghum (Dura) that authorises a high national market absorption capacity for the local production. The other products kept from two years a sustainable demand, linked to the increasing importance of the impact of the dry seasons.

4.4.2 Subsidies and credit facilities

Credit organisations are continuously controlled by governmental bodies. Following the Agriculture Revival Plan, established in 2006 for five years, the credit system is widely financed by Ministry of Finance & National Economy with the relay of Agricultural Bank of Sudan. This general framework is used to share out subsidies in order to help the farmers for their input purchases. With the willingness of reducing production costs, the subsidies are given for the main inputs. They reach 25% of the purchase price for fertilizers and diesel and 22% for seeds. A specific help, 50% of the value, was also given for financing agricultural machinery and tractors. This kind of action is a rough incentive to convince farmers to operate in the scope of a modern agriculture.

For livestock activities it is possible to observe that the present weakness of credit facilities is an effective hindrance complained by stockbreeders. Their needs are essentially focused to engage actions in genetic performance and to organize storage facilities for dairy and meat productions. Following the Policy of Financing Agricultural Activity, and the specific Policies of Financing Agricultural Activities[4], more of SDG 900 Million constituted the unprecedented financing, provided by the Agricultural Bank and other Commercial Banks Matrix, were attributed in 2008 either through direct financing to producers or through forming financing purses with the Agricultural Bank such as financing sesame and sunflower.

The policies also indicated necessity of expanding the scope of micro-financing through the Central Bank of Sudan and the other specialized Bank such as Family Bank and Savings Bank. The latter has witnessed remarkable progress.

With respect to micro-finance activity, the Central Bank of Sudan policy has encouraged the Islamic and conventional banks to allocate 12%, as a minimum of the finance portfolio, at any time, to the micro-finance sector, in the context of directing more resources for mitigating the burden of poverty. As to the establishment of micro finance directorates or units at the head offices of banks, nine banks have established micro-finance units.

For the future, and especially through 2008-2011 Plan, it is requested :

- Allocating and ascending percentage not less 20% of the Agricultural Bank's Resources for financing animal and fishery resources.
- Providing short-term financing for vegetables, medium-term for financing fruit and long-term financing for storage, cool transport for horticulture, dairy and meat products.
- Financing the support services such as research, guidance, and technology transfer.
- Approving the village centre for structuring mobile financing of the Agricultural Bank.

In the field of animal production the government support is focused towards the infrastructure (pools for providing drinking water for animal) and supporting services (vaccination programs). In irrigated areas the Farmer's Commercial Bank can help the farmers to obtain credit facilities. Generally the decision of credit attribution and the interest rate are the result of a collegial dispute between Ministry of Water Resources and farmer trade unions. The interest rate can vary from 10% to 15%.

[4] The Executive Program for Agriculture Revival in 2008 identifies nine main administrative performances, amongst them the first one "setting up production favourable environment" describe targets for the Policies of financing agricultural activity and the Policies of reducing Production costs.

5. PROJECT RATIONALE AND OBJECTIVES

5.1 PROJECT RATIONALE

In order to achieve its goal of reducing and preventing poverty, improving rural incomes and enhancing food security the Government has placed high priority on increasing food production through the expansion of irrigated agriculture. The Project was selected from a range of projects that were identified by the Government. Details on the selection procedure and selection criteria are presented in chapter 2.2. In addition to the development of an irrigation infrastructure the most effective means of improving farm income and preventing poverty is through increased agricultural productivity and improving marketing conditions. An integrated approach was adopted that combines irrigation infrastructure, land and water management under supplementary irrigation, crop diversification and intensification with emphasis on high value crops, improved agricultural practices and improvement of accessibility. Moreover, conditions would have to be created to ensure that pastoralists and livestock production are not negatively affected by agricultural development.

The Project area and its surroundings are characterised by a low population density, low and unreliable rainfall, limited potential for improvement of traditional flood recession cultivation, a fast growing population, an important presence large farmers from outside the area and a large and important presence of pastoralists. All these conditions are most likely to lead to more intense conflicts between local population, immigrating large scale farmers and pastoralists.

5.2 PROJECT OBJECTIVES

The overall goals of the Project are to increase rural income, reduce poverty, and improve health in the Project area and surroundings on a sustainable basis. This applies to local population and pastoralists.

In order to achieve these goals the main purposes have been defined as follows:

- Mitigate and reverse the adverse impact of periodic drought;
- Develop 7,500 hectares of land for supplementary irrigation and create conditions for future dry season irrigation;
- Improve existing wet season cropping systems, supported by crop diversification so as to improve crop productivity.
- Improve crop productivity through better management of soil and water resources.
- Introduce high value food and industrial crops.
- Improve conditions for pastoralists and livestock production.

6. THE PROJECT WORKS

6.1 LOCATION OF THE COMMAND AREA

The area is located on the eastern bank of Rahad River, between latitudes 1,472,500 - 1,478,000 m., and longitudes 678,000 – 695,000 m., in zone 36 P – WGS – 84. It extends southeast of the railway line at Hawata town. The area is flat vast clay plain with a gentle slope from East to West and from South to North. The command area of the region starts at Wad Meskin village at level 455.0 m. A few outcrops are scattered towards the Eastern boundary of the plain. In general the climate of the project area is arid and semi arid and Savannah type where the area is characterized by its high temperatures almost all the year around. The highest temperature is experienced during the months April – May when the mean daily temperature is 32.9 ^{0}C. The project area has an average annual rainfall of 600 mm maximum. Precipitation normally occurs during the period June – October with the heaviest falls during the period of late July to early September. The dry period normally extends from 7 to 8 months from November through to early June. The whole project lies within the semi arid belt. South of Hawata Town the dominant tree species area Acacia Seyal (Taleh) and Balanites Aegyptiaca (Heglig) especially in flat and depression locations. On the other hand pure stands of Acacia Mellifera (Kitir) are observed in the slightly higher plain. Along the Rahad River Acacia Nilotica (Sunt) is prevalent.

The whole area is a well known grazing area for nomadic tribes and the most common pastoral species to be found are Cymbogogan Nervatus (Naal), Cymbogogan Proximus (Mahareeb), Ocimum Basilicum (Rehan) and Sorghum spp. Also such grasses like the Sporobalus spp. are prevalent. Livestock owners still adopt the nomadic system of production, moving inside the Butana plain during the rainy season and coming back to the towns and villages near the Rahad River in the dry season in winter and early summer.

In general the whole area of the project is unregistered government land which is subject to the State right of utilization or lease to potential investors in agriculture. At present this land is marginally utilized by nomadic, livestock owners living in the area and also shifting cultivation is practiced. In areas where rainfall is adequate for sorghum cultivation illegal mechanized sorghum and sesame production has been introduced in the fringes of the area. Close to the Rahad River more intensive crop production is practiced in the form of small fruit gardens growing mangoes, citrus fruits and guava. Winter vegetables are also grown inside the River basin when the River flow stops. The irrigated schemes around the project area are mainly Rahad Phase I Project at the North and some of the Blue Nile pumps schemes on the Eastern side of Blue Nile. Rahad Phase I is of 300,000 Feddans irrigated from Rahad River during the flood season, however, the scheme is supplementary irrigated from the Blue Nile River by Maina pumps through Dinder siphon and Abu Rakham barrage.

6.2 IRRIGATION AND DRAINAGE

6.2.1 Water Requirements, Efficiencies, and Design Flows

6.2.1.1 Availability of Data

Flow data by decade for the Rahad and Dinder Rivers are available for the period from 1912 until 2009.

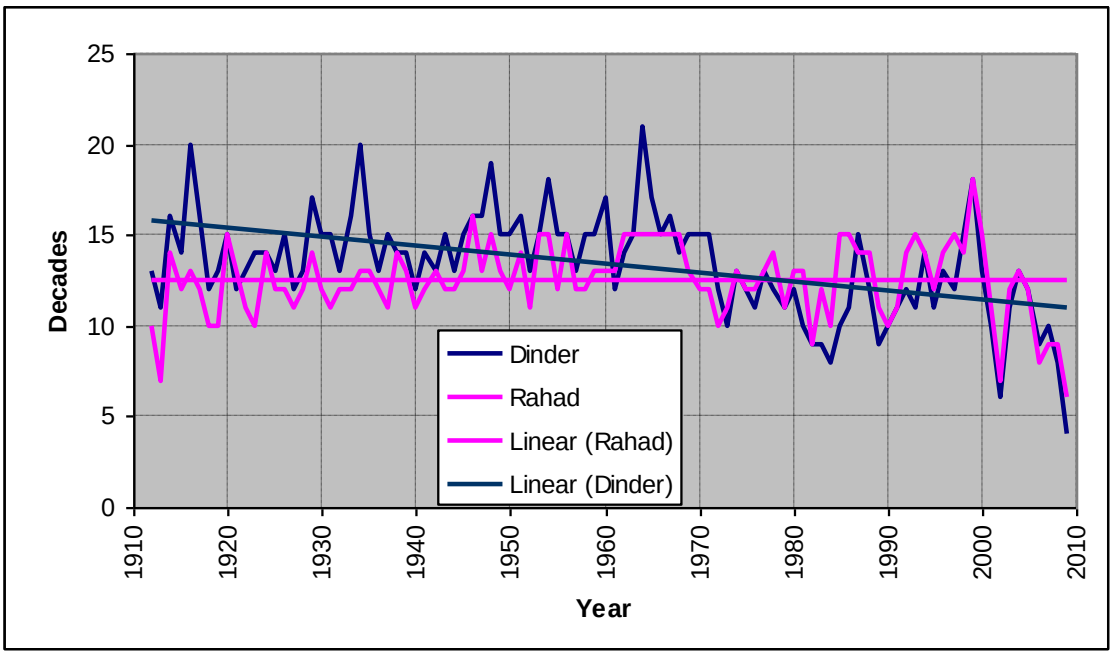
6.2.1.2 Description of Catchments

The catchments of the two Rivers are adjacent to one another with the major and most productive part of the catchment in the Ethiopian Highlands. The two Rivers have their source close to Lake Tana. Both Rivers are ephemeral with flow normally for four to five months a year, but with extremes ranging from a minimum of two months to a maximum of six months.

6.2.1.3 Analysis of Data

Since it is proposed to take water from both Rivers for the irrigation of the Wad Miskeen project, the data have been analysed by comparing the flows in the two Rivers year by year to examine the total period that water is available for irrigation. For this analysis, the flow per decade that was assumed to be sufficient to provide an irrigation of the whole Wad Miskeen area was taken as 7.5 MCM/decade (equivalent to an average flow of 8.7 m^3/s). The number of decades during which the flow in the Rivers equalled or exceeded this figure is shown in Figure 6.1.

Figure 6.1: Decades during which flow equals or exceeds 7.5 MCM



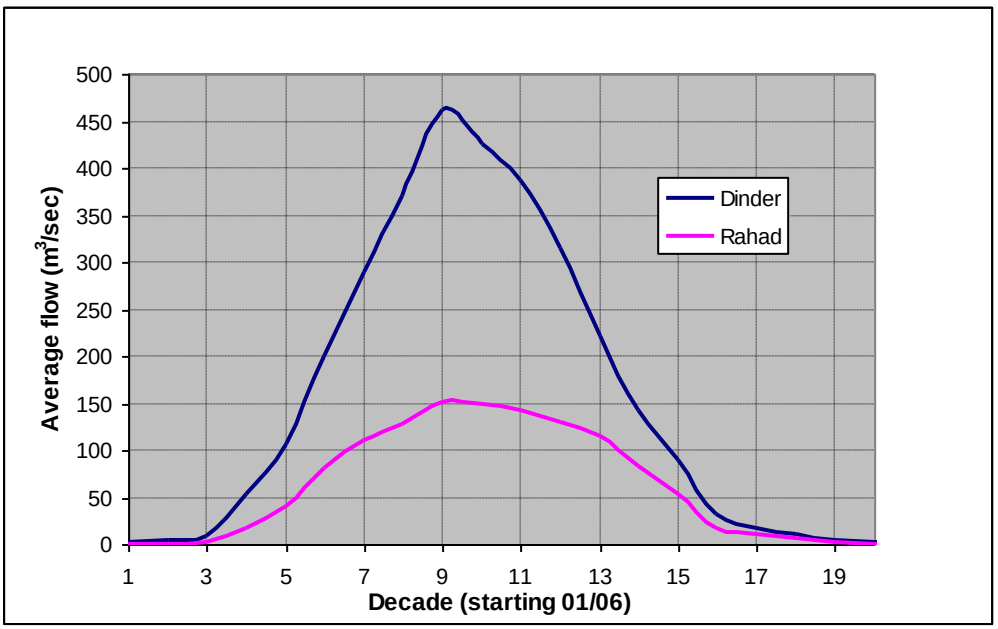
From Figure 6.1 it can be seen that, in the period from 1912 until 1970 the number of decades that the Dinder had water exceeds the number of decades that the Rahad had water consistently and, over this period, the number of decades for both Rivers increases slightly. After 1970 there is a dramatic fall in the number of decades that the flow exceeds 7.5 MCM and, after 1973, the number the number of decades with the required minimum flow in the Dinder only exceeds the number of decades in the Rahad only three times, in each case by one decade.

Overall the trend line of the Rahad remains constant at about 12 decades in spite of the occurrence of extreme droughts in recent years, whereas the trend line for the Dinder indicates a fall from some 16 decades to about 11 decades The reasons for the fall in the duration of the floods on the Dinder may be due to the degradation of the catchment upstream. Since the catchments of the two Rivers are adjacent to one another, climate change is unlikely to be the major cause.

6.2.1.4 Timing of Floods

In spite of the fact that the Rahad catchment lies to the north of the Dinder catchment, there is no appreciable difference in the timing of the floods of the two Rivers. This is clearly shown in Figure 6.2.

Figure.6.2: Mean Floods of Dinder and Rahad Rivers



6.2.2 Conclusion

Rahad flows will stisfy Wad Misken area of 7,500 ha with the construction of the Wad Misken barrage. The flows available for irrigation at Wad Miskeen are dependent on both the condition of the catchment in Ethiopia and any construction works carried out upstream in Ethiopia, particularly irrigation development or the construction of dams, will affect the flow in the Rahad. The construction of the barrage on the Dinder and the link canal will serve the potential area of Wad Misken (100,000 ha).

6.2.3 Water requirements

6.2.3.1 Climatic Data

It has not been possible to obtain detailed climatic data for the meteorological stations nearest to the Wad Miskeen site within the time frame of this study. Standard ETo data for Singa from the FAO database has therefore been used together with average rainfall from Hawata. The data is shown in Table 6.1.

Table 6.1: Climatic Data

Month	Singa ETo (mm/day)	Hawata Rainfall (mm)
Jan	5.58	0.0
Feb	6.27	0.0
Mar	7.2	0.0
Apr	8.17	1.2
May	7.86	15.1
Jun	6.71	99.5
Jul	5.62	154.1
Aug	5.16	201.7
Sep	5.39	79.5
Oct	5.79	15.8
Nov	5.63	0.6
Dec	5.12	0.0

6.2.3.2 Cropping Pattern

In order to determine the cropping possibilities and crop rotations to be adopted in Wad Meskin project, a number of important factors related to agricultural production have to be carefully considered. Special consideration has to be made to the following:

1 The adaptability of the chosen crops to the climatic and soil types of the project. In this regard, a number of crops are successfully grown in the Rahad Scheme under irrigation and in the Mechanized Rainfed Schemes. These include sorghum, groundnuts, sesame, sunflower and vegetables.

2 Food Security: Sudan Government adopted policies to achieve self-sufficiency in all food crops which makes it of utmost importance to grow food crops in any agricultural enterprise. Sorghum is the main staple food for most Sudanese and vegetables constitute an integral part of a balanced diet. The other crops, namely groundnuts, sesame and sunflower also contribute to food security despite that fact that they are considered as cash crops i.e. through their edible oil or their consumption as food.

3 Revenue Generation: Cash crops the generate income for the farmer should be included as part of the crop mix. These crops should have a reasonable demand in the home and export markets. Sudan in the home and export markets. Sudan has established world market for groundnuts, sesame and sunflower.

4 Diversification of agricultural production by production of a combination of food crops and cash crops bearing in mind the need for maintenance of soil fervidity, pest and disease control and reduction of risks and uncertainties.

5 Experience Acquired by farmers: Farmers in the project area used to grow different crops depending on rainfall. They acquired experience with the cultivation of these crops which are namely sorghum, sesame and vegetables.

6 These crops qualified themselves to be part of the crop mix of the project as food and cash crops but the experience of the ferment with them added to their chances to be part of the project.

7 Availability of irrigation: Supplementary irrigation is the kind of irrigation that will be adopted for the project. Water will be directed from Rahad River using a barrage.

The nature of the flow of the Rahad River, the amount of discharge and the length of time irrigation water is available are important factors to decide the type of crops to be grown. How long the crop lasts from sowing to harvest is an important parameter for selection.
Rainfall in the project varies from 400 – 500 mm. It generally extends over the period June to October with the heaviest falls concentrated in the months of July and August while the months of June and October is characterized by low and erratic precipitation.

The cropping pattern used for the calculation of the water requirements is given in Table 6.2. Sesame is used as a typical oilseed crop. Sunflower might be substituted for part of the area planted to sesame, but since sesame is the commonly grown oilseed at present this crop was used for the calculation of crop water requirements. Cabbage is used as a typical vegetable crop.

No allowance is made for irrigating the forestry areas, although some watering will probably be required during the establishment of the trees. The current practice for rainfed farming is to wait until there has been sufficient rainfall to close the cracks in the vertisols before cultivating and sowing the crops.

Table 6.2: Cropping Pattern for Water Requirements

Crop	Percentage of area	Duration (days)	Assumed planting date
Sorghum	33	120	08/07
Groundnuts	33	140	15/07
Sesame	14	100	22/07
Vegetables (cabbage)	15	100	22/07
Forestry	5	perennial	-

It is assumed that this practice will be continued even after the establishment of the supplementary irrigation infrastructure; it appears likely that the first rains will fall before there is sufficient flow in the Rahad to carry out a pre-cultivation irrigation.

6.2.4 Calculation of Crop Water Requirements

The FAO programme CropWat 4.3 for Windows was used to calculate the crop water requirements. The table below shows that between May and December the supplementary gross water requirement at an efficiency of 50% amounts to 254 mm, equivalent to 2,540 m3/ha. The maximum flow would be 0.6 l/s/ha which would occur by the end of September.

Table 6.3: Calculation of Crop Water Requirements

25/11/2009 CropWat 4 Windows Ver 4.3

Crop Water Requirements Report
Crop # : [All crops]
Block # : [All blocks]
Calculation time step = 10 Day(s)
Irrigation Efficiency = 50%

Date	ETo	Planted	Crop	CWR	Total	Effect.	Irr.	FWS	7500
	Area		Kc	(ETm)	Rain	Rain	Req.		ha
	(mm/period)	(%)		----------	(mm/period)		----------	(l/s/ha)	m^3/s
31-May	69.39	0	0	0	0	0	0		
10-Jun	67.72	0	0	0	0	0	0		
20-Jun	65.96	0	0	0	0	0	0		
30-Jun	64.15	33	0.1	1.26	2.88	2.34	0	0	0.0
10-Jul	62.35	49.5	0.17	10.26	24.78	18.6	0	0	0.0
20-Jul	60.6	89.2	0.37	22.23	52.39	36.25	0	0	0.0
30-Jul	58.96	95	0.47	27.76	61.58	41.07	0	0	0.0
09-Aug	57.44	95	0.63	36.4	62.03	41.84	0	0	0.0
19-Aug	56.09	95	0.84	46.95	55.82	39.66	7.29	0.12	0.9
29-Aug	54.93	95	0.98	53.82	43.86	33.8	20.02	0.33	2.5
08-Sep	53.98	95	1.02	54.96	28.98	24.59	30.37	0.5	3.8
18-Sep	53.24	95	1.03	54.72	15.19	13.94	40.78	0.67	5.0
28-Sep	52.72	95	1.01	53.12	6.4	5.1	48.02	0.79	5.9
08-Oct	52.43	95	0.93	48.66	4.53	0	48.66	0.8	6.0
18-Oct	52.34	88.4	0.72	37.45	6.59	0	37.45	0.62	4.7
28-Oct	52.44	38.8	0.29	15.44	2.08	0	15.44	0.26	2.0
07-Nov	52.72	33	0.21	5.53	0	0	5.53	0.18	1.4
17-Nov	53.13	0	0	0	0	0	0		
27-Nov	53.65	0	0	0	0	0	0		
Total	2272.89			468.56	415.96	367.1	253.57	[0.33]	

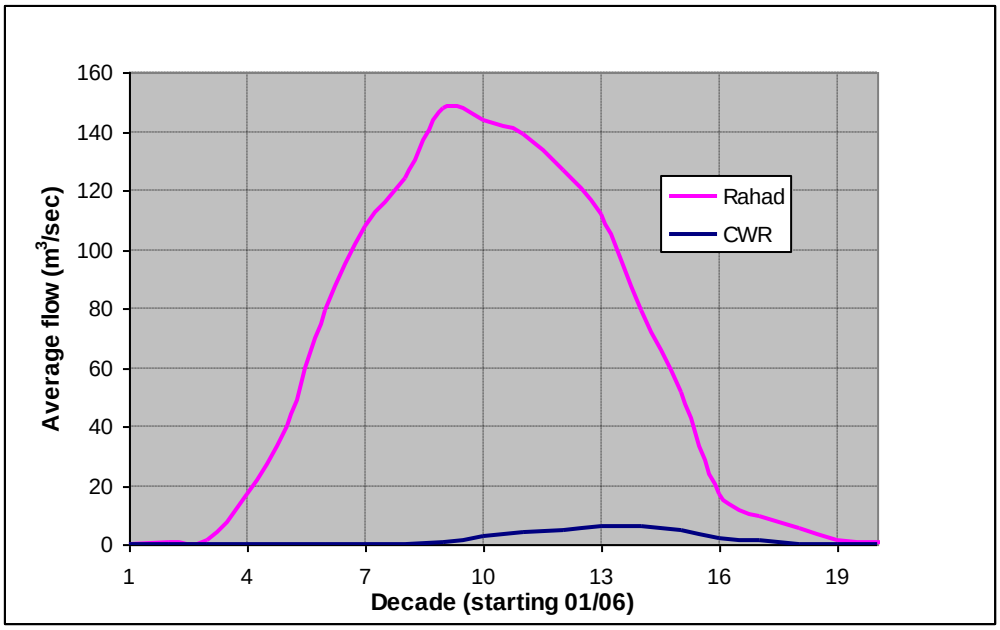
ETo data is distributed using polynomial curve fitting.
Rainfall data is distributed using polynomial curve fitting.

C:\CROPWATW\REPORTS\SINGA\FULLPAT2.TXT

A comparison of the calculated crop water requirements and the mean flow in the Rahad is shown in Figure 6.3.. From this it can be seen that, firstly, the crop water requirements are small compared with the flow in Rahad and secondly, the earlier that the crops are planted, the greater the chance that there will be water for the final irrigations.

It is anticipated that the irrigation cycle will be about 20 days at peak water requirements so that if the last irrigation is completed before the end of October (end decade 15), there should be adequate soil moisture for the first two decades of November (decades 16 and 17) after which there are no crops in the ground.

Figure 6.3: Comparison of Crop Water Requirements and Rahad mean flow.



6.2.5 Design Flow

The peak water requirements are calculated as 6.0 m3/s. The canal system is designed for a maximum flow of 10 m3/s for two reasons, firstly since the flow in the Rahad may be irregular it is desirable to be able to carry out an irrigation quickly when there is water available in the River and secondly, if it is found that the Conveyor Canal to the Rahad II and Rahad North irrigation areas passes by the Wad Miskeen irrigation area, it will be possible to supply the Wad Miskeen area with irrigation water from the Conveyor Canal during the dry season, in which case the full capacity of the canals will be utilised. At the time of preparation of this report no information was available to determine the exact route of the Conveyor Canal, in spite of many efforts of the Consultant.

6.2.6 Salsa Diversion Structure

The barrage is located on Dinder River just downstream Dinder National Park. The function of the barrage is to control the River flow and water levels to enable water to be diverted through the link canal head works.

The barrage is designed to pond and maintains water levels at RL 454.0m and to pass a flood discharge with a 100-year return period of 1000 m^3/s with an upstream afflux not exceeding 0.30m. The barrage, which is of reinforced cement concrete, is designed to have 22 bays, 4m wide each equipped with roller sluice gates to control water levels and discharges.

Sediment sluicing facility is also provided to sluice bed load sediment (mainly sand) in front of the link canal head works. A divide wall is provided to separate the sluice way from the main body of the barrage.

Although geotechnical investigations revealed that seepage underneath the structure is expected to be low, nevertheless, sheet piles are provided along the bottom of the upstream cutoff wall running the full width of the barrage as a further safety measure. Also heavy riprap gabions are provided at the location of seepage exit. A 4m wide heavy road bridge is also provided.

Provision is made for energy dissipation downstream the barrage by a USBR modified type IV stilling basin with chute blocks, baffle piers and dentated sill all of reinforced cement concrete. Pitching protection is to be provided downstream the energy dissipater and in the upstream side of the barrage. Suitable training of the River in the vicinity of the barrage will be made by compacted earth bunds protected by stone pitching where appropriate.

6.2.7 Diversion Head Works at Salsal

The head works of the link canal are located on the outer bend of the Dinder River at the barrage site-just upstream the barrage sluices. The axis of the head works makes an angle of 60 degrees with the barrage axis. The head works will comprise six roller sluice gate openings; 4.0 m wide each separated by piers. The reinforced cement concrete structure is designed to pass a flow of $100m^3/s$ with a head difference of 0.60 m. The structure supports also a heavy traffic road bridge, 4 m wide. The apron level of the head works is set at the same level as the barrage crest level i.e. 1.0 m above the sluice way invert. A breast wall is provided at the upstream side of the gates in order to reduce the gates height and to stop high floods from damaging the head works or the link canal. For the design diverted flow, only riprap protection is needed downstream the head works.

6.2.8 The Link Canal

This is an open earth canal linking the two barrages at Salsal and Wad Meskin on Dinder and Rahad Rivers respectively. Its function is to convey part of Dinder waters to Rahad. The design flow of the link canal is $100m^3/s$. It is 53.8 km long. The link canal route follows the original Mc Donald's canal route except in the first 9 km of its length. In its route, the canal crosses a number of khors; notable among them is Al Atshan. The natural ground slope along the canal route is about 0.10m/km. The link canal, for supplementary irrigation an area much larger than Wad Meskin, is expected to operate intermittently during the rainy season.

Accordingly, heavy siltation is anticipated. In order to get rid of the fine suspended sediment that manages to enter the head works, and makes it to deposit at some specified places, provision of a settling basin in the head reach of the link canal is necessary. A settling basin there is important in reducing future maintenance costs: firstly by confining sediment clearance works at the head reach only instead of all along the canal length; secondly the maintenance of El Atshan siphon, with reduced suspended sediment load in the flow will be much easier and less costly.

A wide and long settling basin is needed to settle suspended sediment in the range of very fine sand and smaller i.e. wash load. The longitudinal bed slope of the link canal is therefore made flat with a slope of 4cm/km and its bed width is made wide in order to settle a significant part of the suspended wash load. Calculations indicate that a basin having a bed width of 40m and a length of about 26.5km and a flow depth of 3.83m with side slope 2H: 1V is needed in order to settle down suspended sediment down to the size of coarse silt.

After the settling basin, between km 26.623 and 38.296, the link canal will have a longitudinal bed slope of 8.6cm/km and a trapezoidal cross section with bed width of 30m, normal flow depth of 3.58m and side slope of 2H: 1V. This particular longitudinal slope was determined so that the resulting mean velocity (0.75m/s) will be the maximum allowed for the type of soil i.e. black cotton soil.

At station 38.296km, the link canal crosses underneath khor El Atshan by a siphon. Thereafter, the same canal cross section is maintained up to the canal outfall at km 50.0. The outfall is a gated structure in every aspect very similar to the canal head works at Salsal. The outfall structure serves two purposes: to control the flow into Wad Meskin barrage pond, and to prevent the ponded water from getting into the link canal when the latter is dry.

The suggested settling basin at the head reach of the Link Canal is very similar to the supply canal of Rahad Phase I project where the design discharge was 105 m^3/s with bed width of 35 m, normal flow depth of 3.5 m and a longitudinal bed slope of 5 cm/km. This supply canal experienced siltation in its entire length particularly in the first 20-30 km. In its operation life of about 35 years, the canal needed to be desilted only once. Because of the hydraulic similarity between the supply canal of Rahad Phase I and Wad Meskin Link canal, de-silting in the link canal is expected to be quite infrequent given the nature of sediment in transport by both the Blue Nile and Dinder rivers. Thus the cost of de-silting work will be quite reasonable.

The design of the Link canal doesn't deviate significantly from that of regime canals with cohesive bed and banks as the following Table 6.00 shows for a design discharge of 100 m^3/s with appreciable suspended sediment load (mainly wash load) during the rainy season.

Table 6.4: Comparison between Link Canal and Regime canal

Design parameter	Wetted perimeter	Hydraulic radius	Long. Bed slope
Link Canal (settling basin)	57.1 m	3.19 m	4.0 cm/km
Link Canal (d/s settling basin)	46.0 m	2.89 m	8.6 cm/km
Regime Canal	47.0 m	2.94 m	6.8 cm/km

The route of the link canal in its first few kilometers requires considerable excavation to cut through relatively high terrain. This is unavoidable for three reasons:

1 Moving the chosen barrage site further upstream is not possible as the present location of the barrage is just outside the boundary of Dinder Reserve Park.

2 If the barrage site is moved further downstream, then the retention level will be less and consequently the command between the two barrages will decrease.

3 If the barrage site is moved downstream, considerable and costly river protection work will be required to protect villages like Um Bagara which was the initial site chosen for the barrage and later discarded in favor of the present site at Salsal.

For these reasons, the present site of the barrage is a good compromise between the capital expenditure of the construction work needed for the suggested canal route and the long-term loss of command and permanent threats to villages like Um Bagra.

6.2.9 Khor Atshan Crossing

This is the biggest crossing in the route of the link canal. El Atshan is a very meandering ephemeral stream. Its watershed is un-gauged. Because of the uncertain estimate of the khor's peak runoff, it is decided to pass the link canal underneath the khor by a siphon to avoid any risk to the canal if it is allowed to pass over the khor. Further, it is better to avoid interrupting the course of a natural stream because the impact of doing so cannot adequately be quantified.

The siphon will be a reinforced concrete multi-cell barrel structure. There will be three square barrels, each 3.4x3.4m very similar to the existing Dinder siphon for Rahad I project. At the inlet, gates will be provided to control the flow into the siphon. At the downstream side, appropriate scour protection by pitching will be provided. At the crossing, Atshan Khor is about 70m wide, while the length of the siphon is about 100-110m. The head loss across the siphon is close to 1.0m.

An emergency spill facility in the Link canal at Khor Atshan crossing, as a safety measure will be incorporated same as the one incorporated in the Wad Misken Barrage since there is a terminal gated structure that controls the link canal inflow to the barrage's pond.

6.2.10 Wad Meskin Diversion Barrage

The barrage site on Rahad River is located upstream Wad Meskin village. At the barrage site, the River reach is narrow and straight.There are gardens on both banks of the River there. The barrage is designed to pass safely a flood discharge of 220m^3/s with a 100-year return period. The retention level is at RL 448.5, while the River bed level there is at RL 445.0. The adopted command level for Wad Meskin irrigation project is at RL 447.5. In its layout, this barrage is very similar to the already existing one at Abu Rakham. The barrage is designed as a reinforced cement concrete (RCC) structure with 9-gated openings, 4 m wide each in addition to a sluice way with two bays also 4 m wide each. The crest of the barrage is set at RL 446.0. The barrage is thus capable of passing the design flood discharge with an afflux of 0.30m in order to protect villages upstream the barrage from high back water effects. Energy dissipation downstream the barrage is by a USBR type III stilling basin. Water will be diverted to the irrigation project through head works located on the right bank of the barrage. The head works have a design discharge of 10m^3/s. The full supply level of the project's main canal just downstream the head works will be set at RL 447.5. A heavy traffic road bridge will be provided to pass over the barrage and the head works. Bunds will appropriately be provided to contain floods upstream the barrage and to protect Wad Meskin village.

6.2.11 Main Canal Head Works at Wad Meskin

The head works here are, in every aspect, very similar to those at Salsal on Dinder River. They will be located on the same side as, but just upstream Wad Meskin project head works. The structure is designed to pass 100 m^3/s.

6.2.12 Main Canal System

The main canal is design according to the Ministry of Irrigation standards which is now operating in the Gazira scheme with an area of one million ha (about 2.1 million feddans, 0.882 million ha) and working with high efficiency for about 80 years. Also Rahad phase I with area of 126,000 ha (300,000 Feddans) and working for 30 years. New Halfa scheme which is now working since the year 1965 and in a good condition. The main canal is designed with capacity of 10m^3/s, taking water from Wad Meskin proposed barrage and extending to Sudan rail way line in Hawatta town. The practice and experience in Sudan shows that no tail scapes are needed to cater for the safety handling of excess flow rejection. All canals systems (main , major and minor canals) were designeed without tail escape structures. The tail escapes experience in Sudan shows that such structures leads to uneconomical use of water by farmers because they do not fear flooding of their crops and the water is discharged in drains, we find empty canals and full drains, the quantity of stored water is just enough for supply irrigation in the rainy season (July –October) i.e. one crop so there is no surplus for drainage in escape drains.

The main canal woud be 37.7 km long and irrigate an area of 7,743 ha; the bed width is 6.00 m with a side slope 2:1. The main canal width is reduced to 4 m from K32.00 to K37.70. The total excavation of earthworks is 299,143 m³. The main canal has two major canals branching from it. There is regional road 6.00 m wide parallel to the main canal usually made with gravel layer 0.2 m.

6.2.13 Major Canals System

The major canals system according to the standard used in the design consist of two major canals with an area of 3,235 Feddan (1,359 ha) for major No. 1 and length of 5.5 km with excavation of earthworks 78,712m3.The off take structures is Moveable Weir Series Two (M.W.II). The bed width is 4.00 m and side slope 2:1. Major No. 2 the area 5,140 Feddans (about 2,159 ha) with length of 5 km and earthworks of 58,700 m^3. The off take structures from the main canal is moveable weir series II (M.W II).The bed width is 4.00 m and side slope 2:1.

6.2.14 The Minor Canals system

There are 17 minor canals some taking from two major canals that are supplied by the main canal. All the off take structures of the minors are pipe regulators (P.R) of size either 0.76m or 0.91 m. The off take structures are pipe regulators and moveable weirs which can give estimation of the quantity of water from head and gate opening. The bed width of all the minors is 2.00 m with side slope 2:1. There will be 15 masonry drop structures. Total volume of earthworks is 543,541 m3. The majors and minors have access roads 3.5 m wide with a 0.2 m thick surfacing.

6.2.15 Tertiary Systems

The tertiary system in the standards of Sudan irrigation systems is called Abu Ishreen (Abu XX) which usually has a length of 1,350 m net and the net distance Abu XX to Abu XX is 280 m ,so the area irrigated by on Abu XX is 280*1,350/4,200= 90 Feddan i.e. 37.8 ha. The off take structures of Abu XX are field outlet pipes (F.O.P) with standard diameters of 0.35 m. The section of Abu XX is standard and usually excavated by a special machine every year during land preparation for cultivation by the authority of the scheme, but the location and off take structures is down by the Ministry of Irrigation. In this scheme the number of Abu XX is 210 with 210 (F.O.P) in the off takes, the number of Abu XX in each minor canal is shown in the table.

Table 6.5: Minor Irrigation Structures

No	Description	Unit	Quantity
1	Pipe regulators	No.	17
2	Moveable weirs	No.	2
3	Field outlet pipes (F.O.P)	No.	210

6.2.16 Drainage Requirements

Protective Drain

The scheme needs drainage to be protected from the flood from outside the project area which may wash out the canals. The scheme area needs to be drained from the excessive irrigation water and from rain water. To be protected from outside floods a protective major drain is included in the canalization of the scheme. The protective drain is to direct the flow coming from the high lands which is intercepted by the project to be directed to Rahad River between the scheme and Hawatta. The protective drain is with single bank on the project side acting like dike. This drain is shown parallel to the main canal from outside extending from Wad Meskin to Hawatta with its outfall in the Rahad River. The earthworks of the protective drain are 498,759 m3 with single bank between the drain and the main canal. The protective drain is executed with one section, the length of the protective drain is 47.5 km with bed width 4.00 m and depth to dig is 1.5 m i.e. the area of cut 12/2*1.5 = 10 m^2 with single bank.

Minor Drains

The project area is drained by minor drains running parallel to the minor canals executed with one section. The length of minor drains is 50 km. The area served by each drain is the area of the minor irrigating the same area. The section bed width 1.00 m, depth to dig 1.00 and area of cut 6/2*1 =3.00m. The total cubes of excavation are 150,000 m3. All these minor drains are collected in a collector drain to drain in Rahad River. In the cost estimate there are 20 concrete pipe culverts for the crossing of drains and roods.

6.2.17 Operation & Maintenance Aspects

Management Functions

Recently, the government of Sudan adopted a privatization policy in the agricultural sector.

According to this, the role of the government in the project will be to provide irrigation water up to the minor canals, general supervision of the field to ensure rational use of land and adequate observation of agricultural laws and regulations by all farmers besides providing extension and technology transfer services. Accordingly, the project management will assume the following functions:

- Project general supervision.
- Regulation of the supply of irrigation water to the minor canals.
- Supervision of the flow of water in field outlet pipes to ensure rational water use.
- Maintenance and up-keep of major and minor canals.
- Provision of extension and technology transfer services.
- Provision of agricultural engineering and plant protection advisory services.
- Collection of water and administrative charges.
- Enforcement of agricultural laws and regulations.

In order to carry out these functions an administrative set up headed by a general manager, who must be a qualified experienced person, supported by subordinates to carry out the management functions mainly in the following functions:

Agriculture and Field Function

This function includes extension, farm machinery and plant protection services and it includes:

- To ensure adequate field supervision and field extension services.
- To assist in the application of field machinery practices and output measurement
- To monitor the nay diseases in the field and establish plant protection practices.

Irrigation and Water Management function

This management function is concerned on the supply of irrigation water in the adequate time, quantity and build coordination with the WUA in the project as below:

- operate and maintain the irrigation system and its structures
- coordinate with the WUA
- calculate and report water demand for the field

Finance and Personnel Administration

This function looks on the administration and finance maters with the following responsibilities:

- Manage the HR resources
- Collect water and management fees
- Control income and expenditure of the project

6.3 AGRICULTURAL DEVELOPMENT AND FARM MECHANISATION

Mechanization of some cultural practices in this project becomes a necessity in order to reduce cost, save time and perform the required specification of the practice. The availability of tractor and farm implements, the skilled labor, the technical back- up and the technical recommendations make performing the mechanizable operation a good option. In this project since farmers are an inherent component in the production system, it was agreed that labor intensive, difficult operation and time consuming practices should be mechanized include, seedbed propagation, seeding fertilizer application ,herbicide application ,harvesting and transport of inputs as well as produce. Mechanized operation will be arranged by an agricultural engineering unit either connected to the project or to any agricultural service company.

6.4 INFRASTRUCTURE DEVELOPMENT

6.4.1 Physical Infrastructure

Sudan Government strategy aims to develop the most remote areas in the country. Infrastructures like roads, water supply, health services and education are very important to the government strategy. National strategy of the Sudan aims to develop all economical and social aspects, it aims to raise the GNP and develop the agricultural, mining and industrial resource in Sudan. Many development projects are being planned and implemented all around the country. As roads networks are needed for the product transport as well as the transport and inter project transportation. Usually simple and low cost roads are built within the project area. People travel between villages and local markets by small trucks and busses to go back and forth Hawata city and other villages; in the rainy season mainly tractors are the main transport facility even in emergency cases.

The existing road network covers the area around the project area with a main focus to Hawata city, there are field roads that spread out in the area and changes route frequently due to the result of the rainy season and mainly generated by the rain fed agriculture since it is used to transport products. The inter villages roads follow the Riverbank to link villages which are located at the bank. Riverbank plantations which are mainly vegetables are transported through roads. In most cases animals in the summer season travel from the uplands to the River bank through a defined corridors to water their animals.

The movement of the people during the rainy season is rather difficult. In most of the irrigation projects, raised roads (sub base) along main and major canals are constructed to overcome the slippery muds of clay everywhere. Raised roads will make easy movement of farmers so that they can reach their farms during cultivation and harvest periods. The construction material of the raised roads are borrowed either from canal excavations or from nearby areas using domer machine. It is considered in the design of the irrigation and drainage system to build crossings and corridors to enable animals to pass to the Riverbank for watering and these crossings and corridors are considered as a part of the irrigation and drainage design and cost. In the field of communication, Sudan has a modern network of communication facilities; there are four working providers of communication facilities, internet and other communication media. There is a 220 KV electrical transmission line from Singa to Gadarif passing through Hawata Town.

The area surrounding Hawata will be electrified as there is amble power from Merowe dam. The project area will be connected to this national grid from the transformer station near Hawata. Hawata is the main market centre in the area, fresh vegetables, fruits and other products are marketed at Hawata to whole sellers who transported to consumer centres up to Khartoum. The other crops like sorghum, sesame and others are transported to Gadarif which is the central market in the area.

6.4.2 Social Infrastructure

The project area is poor in social services. The field survey in 10 villages in the area showed that there are four (4) basic education schools, three (3) primary health units, one (1) dispensary and two (2) villages supplied by Hawata network water system. Most of the villages depend on River Rahad for drinking water. The area is not only poor in social services but lack dependable means of transport to markets or Hawata Town. The area is totally out of reach during the rainy season. Lack of social services is also reflected in the level of environmental health and spread of diseases like Malaria and Diarrhea particularly among the children as reported by the only medical Assistant living in the area.

Health facilities were spread out to raise the health standards and to localize the health and medical services, many new equipment are brought and installed in most states and medical staff was trained to operate and maintain them. Educational facilities like schools institutes and universities were built in all the states, town and villages so as to make education as near as possible to all citizens. Roads to link the country states were built to facilitate products transport inland and for export beside to make land transport and travel easy within the country large area. Water resources were studied to provide clean drinking water for both the human beings and the animal resources available and programme of water harvest is developed and many water harvest projects were built. These social services shall consider the needs of the society, shall be studied and evaluated in the environmental and Social Impact Assessment (ESIA).

Although the villages in the project area have, hand pumps water wells as a source of water but in most cases, they use water directly from the River for the human use and animals.

These water resources are limited in quality and quantity, the River water is raw water, which changes quality in the rainy season due to the flood and is not that hygienic since it is not treated. The livestock is also using these resources especially in the summer time where water is rare uplands and all move to the Riverbank. It is important that villages within the project area be within easily reach of water sources whether surface or ground. According to the ground water aquifers in the area. The existing water supply system is a set of hand pump wells and the River water. The hand pumps are used due to the non-existence of power and cost of the diesel engine, which can be used instead as a driving source.

In the upland areas, small hafirs are located and they are mainly used by the rain fed agriculture work force for drinking and used by animal growers but they small and dry in a short time after the rain stops. The existence of an agricultural project with water canals and plantation will generate water related diseases that affect inhabitants and their animals. There are many water diseases, which can prevail in the project area due to the existence of the irrigation and drainage system. Diseases like malaria, belharzia, diahrehia, gardia and others are expected to prevail in the area.

Existing Medical and Health facilities

The health services available at the project area are poor and located at Hawata City where there is a central hospital, small clinics and private clinics are there.

In the hospital, there are inpatient and outpatient services with specialist doctor's clinics to serve the population. Major cases are referred to Gadarif City the State Capital, to Wad Medani Gazira State capital, or directly to Khartoum. In villages there are small clinics that are operated by a senior nurse.

Education needs are of great importance to the people young generations in the project area. The project area although has some educational services but it is located in Hawata city mainly specially the secondary school level, it is recommended that educational services being extended to a wide area other than Hawata village. The existing educational services are composed of a pre-education schools (Khalwa) which are created and managed by the Sheikh who is a religion leader; these pre-schools are meant to teach basic Arabic, basic mathematics and Quran sciences. These institutions are financed many by donations and village sharing and they are not considered within the formal school setup. Basic school education exists in major villages that students travel daily to attend it. Secondary school education is available only at Hawata City both for girls and boys education.

Pre-schools, basic schools and secondary schools shall be made available for the kids to carry on with their education to get better chances for university and higher education in the future. Two preschools each with 40-student capacity are needed with all necessary equipments, furniture, toys, playgrounds etc. to cover the area in a reasonable manner. Four foundations schools two for boys and two for girls are needed to accommodate required number of students. The foundation school will be supplied with all necessary equipments, furniture and other small laboratory equipments. Each foundation school shall accommodate 240 pupils. Two secondary schools one for boy and one for girls are needed to accommodate the available students. Each secondary school is well equipped with all necessary equipments, furniture, laboratory needs etc. The laboratory needs include chemical, biology and physics equipments and necessary chemicals. Above schools shall be utilized for both girls and boys education.

6.5 PROJECT ORGANISATION, MANAGEMENT AND COORDINATION

6.5.1 Organisation and Management

Operation and maintenance of irrigation projects is a tedious job. Wad Meskin irrigation project (7,500 ha) can be considered a rather small project compared to Gezira and Managil (900,000 ha) which is one of the largest irrigation projects in the World under one administration. The project is irrigated by using two large barrages on the Dinder and Rahad Rivers. The waters of the two Rivers is directed towards a link canal and then into the main canal of the project. Minor canals off-take from the main canal to constitute the main network of the project. Main off-take and intermediate regulators are located to regulate the required flows to the field. The personel needed for operation and maintenance for the project has specific tasks which have to be carried out in a proper manner.

Overall Organization and Management. According to the privatization policy adopted by the government in the agricultural sector, the role of the government will be mainly to provide irrigation water up to the outlet of the minor canals and collect the land and water charges from the farmers and a general supervision of the agricultural laws and regulations by the farmers. The actual management of the agricultural activites will be dealt with by the farmers through their unions and Water Users Association (WUA) which shall be formed in theproject area. The project management shall provide extension services. It shall assist technically in mechanical operations for land preparations, shall assist technically in providing agricultural inputs such as seeds, fertilizers and coordinates with the farmers and shall seek and coordinates financial loans to them from financial institutes.

The main points to be considered in the operation and maintenance of an irrigation project have been summarized in annex 10 for the following components :

- Upstream side of the project
- Irrigation canals and drains
- The gross and cropped areas

Machinery, Vehicles and tools. As some of the agricultural operations are mechanized e.g. land preparation, planting and harvesting, the project management shall support farmers technically. Preparation of list of machinery, equipments, vehicles and their spare parts and hence the running cost, for operation purpose and later for maintenance needed is to be made by the project management. The total costs for vehicles and light trucks and miscellaneous equipment has been calculated at 650,000 USD (see annex 11 for details).

Hydraulic Structures. Also the financial and running cost should be known. The proper operation methods will minimize the maintenance cost.

Offices, houses, workshops etc. The numbers, types and distribution of offices, houses, workshops and stores etc. should be determined, located, verified. ouses and workshops distributed and hence evaluated to accommodate the labour force and the project requirements. The fixed cost for the offices, houses and workshop are detailed in Annex 7. Office equipment and furniture require 25,000 USD.

Personnel. The organization structure should meet the requirements needed by the employer and at the same time satisfy the operations and maintenance requirements. The overall organization and management of the project function and elements can be given within the following management personnel :

- Project Manager
- Irrigation Division Engineer
- Sub-division Engineers
- Mechanical Engineer
- Technicians and Agricultural Operations Coordinator

Organization Structure and Management Practice: The main objective of the organization structure for Wad Meskin Irrigation Project aims at establishing an effective organization structure and propose most genuine management practice to operate and maintain it and enable it to achieve its social and economic objectives. All rules and regulations in respect of the management practice, administration, remuneration of the manpower that are currently applied for similar irrigation projects will equally apply to this project. The organization and management of this project will be the primary force for coordinating the human and material resources in order to achieve irrigation targets set for this project. The operation and control of this new plant would certainly require sound management practice and leadership, as well as the application of various management techniques and planning skills that would motivate rather than alienate the work force of this new project, right from the top management of the project down to the shop floors.

The organization of work, the administration and remuneration system, the human resource policy, the training and development programs are all but essential components of managing this new irrigation project to satisfactory standards that will make possible achievement of total project objectives cost-effectively. At the outset, the study recommends that recruitment of the technical and supervisory staff of this project to be conducted in the most impartial manner, and be based on qualification and experience of candidates without regard to any other considerations and/or outside pressures. Manpower costs (and payroll) will be estimated on the prevailing Federal Civil Service System, as approved by the Federal System. The organization structure of this new irrigation project will be the means for attaining irrigation water distribution and targets, allocating work responsibilities, providing a framework for operation and performance assessment of activities and providing mechanism for the efficient operation of the project vis-a-vis. The major components of the functional organization structure of Wad Meskin irrigation project are reflected on the organization chart below. In accordance with the groupings and manpower classification and management the yearly remuneration of each employee in each of the groupings can be estimated at 191,000 USD/year (see Annex 10 for details).

6.5.2 Private Investment Options

Private investment options are very limited because the area is remote from markets. Moreover, the scheme is intended for smallholders.

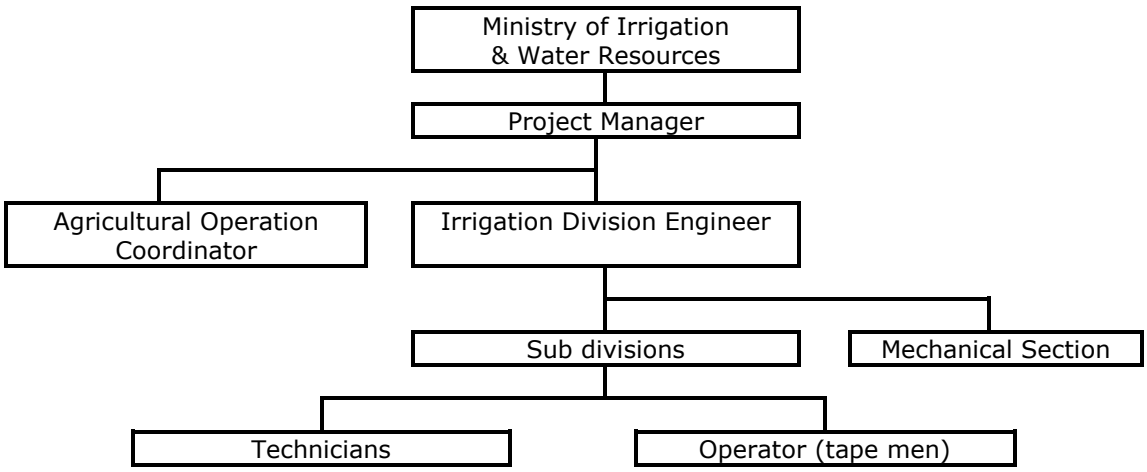
6.5.3 Project Costs

The investment costs for the three phases and the respective unit per ha costs are presented in the table below.

Table 6.6 : Investment Costs for various developments phases

Phase	Name	total area (nett ha)	component	total costs (million USD)
1	Wad Meskin	7,500	area to be developed	
	supplementary		barrage Wad Meskin	2.30
	irrigation		main canal barrage-WM area, 37.5 km	0.92
			irrigation system	30.60
			on-farm development, 200 USD/ha	1.50
			supporting investments	2.00
			subtotal 1	*37.31*
2	Rahad 2	100,000	area to be developed	
	supplementary		barrage on Dindir River	3.85
	irrigation		link canal&associated structures	29.08
			Khor Atchan crossing	0.49
			increase capacity WM main canal. 37.5 km	21.58
			extension main canal, 30 km	18.00
			irrigation system	408.00
			on farm development	20.00
			supporting investment	26.67
			subtotal 2	*527.68*
3	Wad Meskin and	107,500		
	Rahad 2		Roseires link to Dindir barrage, 50 km	35.00
	get dry season		OF development for double cropping	5.38
	irrigation		supporting investment	5.00
			subtotal 3	*45.38*
			total 1+2+3	***610.37***
			note: total costs include 15% physical contingencies	
			unit development costs	***(USD/net ha)***
			Phase 1 Wad Meskin	***4975***
			Phase 2 Rahad 2	***5277***
			Phase 3 WM&Rahad 2 double cropping	***5678***

Figure 6.4: Wad Meskin Irrigation Project Organization Chart



7. AGRICULTURAL PRODUCTION AND MARKETING OPPORTUNITIES

7.1 AGRICULTURAL PRODUCTION

7.1.1 Crop Production

The project area is flat vast clay plain with a gentle slope from East to West and from South to North. A few outcrops are scattered towards the Eastern boundary of the plain the total area of the Rahad plain is approximately one million Feddans and with Rahad II taking some 300 Feddans still there is some 650,000 Feddans awaiting agricultural development.

In general the climate of the project area is arid and semi arid in the scheme and Savanna type in the South where the area is characterized by its high temperatures almost all the year around. The highest temperature is experienced during the months April – May when the mean daily temperature is 32.9 ^{0}c in the southern part and 30^{0}c in the North.

Precipitation normally occurs during the period June – October with the heaviest falls during the period of late July to early September. The dry period normally extends from 7 to 8 months from November through to early June.

The whole project lies within the semi arid belt but the vegetation cover varies with the amount of rainfall and land topography within the area. South of Hawata Town the dominant tree species area Acacia Seyal (Taleh) and Balanites Eagyptiaca (Helig) especially in flat and depression locations. On the other hand pure stands of Acacia Mellifera (Kitir) are observed in the slightly higher plain. Along the Rahad River Acacia Nilotica (Sunt) is prevalent. The whole area is a well known grazing area for nomadic tribes.

In general the whole area of the project is unregistered government land which is subject to the State right of utilization or lease to potential investors in agriculture. At present this land is marginally utilized by nomadic, livestock owners living in the area and also shifting cultivation is practiced. In the Southern part where rainfall is adequate for sorghum cultivation illegal mechanized sorghum and sesame production has been introduced in the fringes of the area.

Close to the Rahad River more intensive crop production is practiced in the form or small fruit gardens growing mangoes, citrus fruits and guava. Winter vegetables are also grown inside the River basin when the River flow stops.

The proposed project is about 7,500 ha net and lies in the Southern end of Rahad I project and it is a part of proposed Rahad II project. It lies between Hawata Town in the North and Wad Meskin Village at the South. The project area lies on the eastern side of the seasonal Rahad River. The Wad Meskin Project site is close to the Rahad Project Phase II which lays within latitudes 13º - 40´ and 15º - 10´ & longitude 33º - 40´ to 34º - 20´ E.

7.1.1.1 Cropping Pattern

Due to the seasonal nature of the Rahad River flow which normally starts early in July and continues to late October yearly, early and medium maturity crop cultivars have been recommended for cultivation in the project. Field crops that normally grow in the rain belt, which includes the project area; have been selected for the project with the objective of increasing productivity and improving the quality as a direct result of supplementary irrigation and use of modern technologies. Summer season vegetables with short or medium life span were selected for cultivation in the project. These crops will contribute positively in improving diet of inhabitants of the area as they can supply all necessary vitamins and materials needed for human nutrition.

The remains of crops after harvest can help animal wealth in the area as a food source of animal feed. At least farmers who own animals may not have to follow a nomadic life any more as they can feed their animals form their crops byproduct. They crops selected for farming in the project area are selected to meet the above objectives and make use of the rains and the irrigation system designed for the project. Economical consideration also was observed beside the farmers experience in cultivating these crops and vegetables. Taking into account the amount and distribution of rainfall in the project's site together with the shortage duration of the Rahad River discharge, which is planned to be utilized for supplementary irrigation, crop option, have to be within these crops, which have a short or a medium duration period for maturation. These characteristics are available in the following crops; some of these crops are already grown by traditional farmers under rain fed conditions in the central clays of the Sudan.

Sorghum: Early and medium maturing varieties are recommended. The most popular are Hageen Dura, Was Ahmed, Gadam Al Tair and White Dwarf Milo. The yield expected is 2 to 4 ton/ha.

Groundnut: Early maturing and draught tolerant cultivars are Sodari and Ghebaish are grown in Kurdofan states under rainfed conditions normally with low yields but with supplementary irrigation conditions the yield is expected to range between 1.0 to 2.4 ton/ha. Medium maturing varieties are MH383, Kiriz, Ahmadi, Tozi, and Medani. These have been released by ARC and characterized by high yields and food quality. Yields range from 2.4 to 3.4 ton/ha.

Sunflower: The crop is successfully grown under rainfed conditions in Damazin area especially under zero tillage system. The expected average yield in traditional rainfed sector is about 0.96 ton/ha while under Zero tillage system it may reach 1.2 ton/ha. Under supplementary irrigation conditions the expected yield is 1 to 2 ton/ha.

Sesame: Several cultivars, especially white seeded are recommended e.g. Kennana2. These cultivars under supplementary irrigation are expected to give an average yield of 1.2 to 2.0 ton/ha.

Vegetables: These include different kinds of vegetable like Okra, Cucurbits (Melon, Watermelon, and Cucumber), leafy vegetables (Rocket, Jewsmallow, Purslane) and sweet Potato. The lifespan duration of the recommended cultivars of these vegetables can easily fit in the project considering the availability of supplementary irrigation.

7.1.1.2 Crop Choice

The choice of crops to be cultivated and adoption of an appropriate rotation shall be made according to sustainable economic returns and other related factors particularly soil moisture availability. However, a three-course rotation is suggested as per Table 7.1.

Table 7.1: Crop Rotation Schedule

Area	First Year	Second Year	Third Year
7,500 ha	Sorghum	Vegetables/Sesame or Sunflower	Groundnut
7,500 ha	Vegetables/Sesame or Sunflower	Groundnut	Sorghum
7,500 ha	Groundnut	Sorghum	Vegetables/Sesame or Sunflower

7.1.2 Livestock Production

Sudan's agricultural GDP includes a contribution of about 20 per cent from livestock. In the north-central part of Sudan which includes the project area, extensive range-based and nomadic or transhumant livestock production has been the main contributor to the provision of animal protein for the Sudanese people and also contributed greatly to export and thus to foreign exchange earnings. Development of the "central rain lands" with large scale mechanized and semi mechanized farming schemes that cut across many traditional livestock movement routes has had negative effects on animal production.

It can be expected that the extension of cropped areas at the expense of grazing land coupled with the development of irrigation and rapid human demographic growth will continue this trend. Sedentary or almost sedentary livestock production systems that associate crops with livestock can, on the other hand, be expected to become more important.

The livestock subsector employs directly or indirectly about 40 per cent of the population and contributes valuable animal protein to the diets of all of Sudan's people. Some 80 per cent of the animal wealth is owned by nomads and transhumant pastoralists. Livestock are a strategic element in livelihoods, income generation, and food security and in agricultural development. People in the Wad Meskin Project Area are either farmers or transhumant pastoralists who move seasonally with their livestock in search of feed and water. Income for both farmers and nomads is low because of the limited output of agricultural crops and livestock products. The situation is aggravated by the large number of Internally Displaced Persons (IDPs) who have been forced into the area as a result of drought, famine and civil conflict in their home areas and real poverty is widespread.

There are two principal production systems. One is based on crop production (small scale subsistence and large scale semi mechanized commercial cereals and sesame) which is mainly rainfed but there is some traditional irrigation) and the other on transhumant livestock production. Crop farmers also keep a small number of livestock.

In the main part of the Project Area water is plentiful during the rainy season but becomes increasingly scarce as the dry season progresses. Pastoralists leave the main part of the project area in the rainy season as their presence is inimical to crop production and they also want to move away from the increasing presence of sucking and biting flies which are vectors of many human and livestock diseases including trypanosomosis. Thus, they move from the south travelling northwards, mainly to the Butana grasslands in July and return southwards in late October when rainfed crops should have been harvested. To facilitate these movements a number of "stock routes" traverse the area. These are mainly inclined in a southwest/northeast direction. Competition for land between cultivators and livestock keepers has intensified in recent years. Although nominally accepted by crop farmers the spread of both subsistence and larger scale semi mechanized farming has led to encroachment onto and partial or total blocking of the traditional stock routes.

Many of the problems relate to access to water.

Animal husbandry ("management"), within the limitations imposed by the environment, are generally good by the large scale livestock owners. The annual transhumance is an example of an adapted management practice. Owners are also aware of disease problems and take traditional and modern steps to mitigate these. Many owners are also aware of the value of supplementary feeding although this is not practised as a general rule because of the expense and difficulty of obtaining concentrates. There are estimated to be as many as 2 million domestic animals at sometime or other in the Hawata area. Sheep are the most numerous animals, followed by camels, goats and cattle. Livestock are all of the indigenous breeds but there have been some administrative attempts to introduce "improved" types by Artificial Insemination of cattle and provision of exotic male goats.

Natural rangeland provides most animal feed but their productivity (and their area) has deteriorated markedly over the years. Among the interacting factors responsible for this have been the increase in rainfed cropping (mechanized and traditional) has increased markedly which has reduced the rangeland area. pastoralists are pushed into marginal areas subject to more frequent drought, declining and less reliable rainfall with fragile areas in the north experiencing much greater changes than the higher rainfall areas to the south and increasing stocking pressure on the remaining rangelands, particularly in the north. The contribution of crop residues partly compensates for this and fallowed crop lands offer better prospects for low cost improvement with exotic legumes, compared with seeding into undisturbed rangeland. Considerable areas of forage sorghum (especially the 70-day 'Abu sabeen' variety) are grown either as a late rains catch crop or on residual soil moisture. As most of this is produced by crop farmers most of it is produced for sale. It is mainly channelled to the local market where it is sold as green or partly dried fodder

The main services to livestock production are in animal health. These are reasonably effective but they are unable to make frequent visits to individual livestock producers because of logistical and financial reasons. The introduction of paravets (Community Animal Health Workers) would improve the situation especially at "first aid" level. Marketing is entirely in the hands of the private sector. Although the system works well producers may sometimes be at a disadvantage in the absence of price information on a more widespread basis.

The productivity of Sudanese livestock is widely reported as low. The parameter most often referred to is usually, however, production and not productivity as there is no reference to input: output ratios. Traditional systems in northern Sudan seem to be rather efficient in view of the constraints in which they operate. Improved productivity would be achieved if more favourable total environmental -- including input supply and availability of extension and veterinary services and economic conditions were to be made available.

There has been considerable research on the genetic potential of Sudanese livestock which has shown the possibilities of improvement. The age old tradition of extensive livestock production and the potential for improved pasture land management and introduction of new techniques and systems such as grazing reserves and cooperatives or producer organizations for pasture management provide considerable opportunity for the livestock subsector.

Further attention to mitigation of some production constraints would greatly help the livestock subsector. Aspects such as whole herd health and not just vaccination would reduce the effects of disease. Amelioration of disease impacts would also enable stock to make better use of the limited feed resources which would assist in increasing livestock output.

Livestock genetic resources are not considered a primary or short term constraint to livestock output. Producer management skills for improved systems of production and their very limited access to information and new and appropriate technology because of poor extension services are factors that will potentially limit production in the future. There are inadequate technical packages for traditional producers and encouraging research results are seldom transferred to the producers.

Much of the productive rangeland has been converted to marginal crop production especially by the proliferation of semi mechanized farming schemes. Many of these cut across the traditional migration routes. The consequent decreased or hindered mobility of the pastoral herds and semisedentarization of the herders in addition to the increased stocking rate lead to a severe degradation of the pasture land. The major epidemic diseases have been contained or at least their containment and eradication is possible. New diseases will undoubtedly appear and existing ones will assume more importance. Provision of more clinical and consulting services to complement the mass campaigns is also needed. Continued vigilance should be the watchword. Livestock genetic resources are not considered a primary or short term constraint to livestock output. Producer management skills for improved systems of production and their very limited access to information and new and appropriate technology because of poor extension services are factors that will potentially limit production in the future. There are inadequate technical packages for traditional producers and encouraging research results are seldom transferred to the producers.

Much of the productive rangeland has been converted to marginal crop production especially by the proliferation of mechanized farming schemes. Many of these cut across the traditional migration routes. The consequent decreased or hindered mobility of the pastoral herds and semi-sedentarization of the herders in addition to the increased stocking rate lead to a severe degradation of the pasture land.

The major epidemic diseases have been contained or at least their containment and eradication is possible. The Pan African Rinderpest Campaign is a laudable example of what determination and good organization can achieve. New diseases will undoubtedly appear and existing ones will assume more importance. Provision of more clinical and consulting services to complement the mass campaigns is also needed. Continued vigilance should be the watchword.

Possible interventions in livestock production include redefining the stock routes and creation of more water points (and ensuring that the resultant improvements are respected by all parties), improved nutrition, the training and use of paravets and provision of a market information system.

The opportunities to be exploited for increased feed and fodder production are:

- a large area of rangeland that compensates to some extent for the intrinsic low productivity of the land;
- a broad range of feed resources including rangeland with a very wide array of genera and species, crop residues and by-products and agro industrial by-products;
- good prospects for low input rangeland improvement and scope for developing improved forage production systems in rainfed and irrigated systems in both mechanized farming and smallholder sectors;
- a good possibility of expanding the limited range of forage species for incorporation into farming systems;
- a clear potential for intensification of fattening in the irrigated crop-livestock system as well as elsewhere; and
- possibilities for improved nutritional value of crop residues using any or several of the well known techniques for intervention.
- The main constraints in feeds and forage production are:
- lack of forage reserves for feed shortage and drought periods;
- inadequate technical support to livestock holders in the project areas;
- inadequate research extension activities related to range improvement;
- low level of involvement of populations in range improvement and seeding activities;
- insufficiency of public funds allocated to range rehabilitation programmes;
- absence of private investment in range infrastructure and management;
- lack of producer knowledge of the nutritional value of feeds and the application of balanced rations; and
- recurrent droughts.

The many possibilities for rangeland improvement include over sowing and the use of a broader range of legumes than currently used. There are also opportunities to produce forages of high nutritional value in the irrigated areas.

7.2 MARKETING OPPORTUNITIES

7.2.1 Crops and outlet options

In Sudan context where local production does not have the capacity to meet national demand[5] a positive opinion is to consider the huge market potential as an unlimited opportunity. It's all the more admitted since the market context is good, as regards quantities to sell and revenues forecasted. From long time, and may be, with more intensive expression from the two last years, the demand reaches high level, notably for cereals, pulses and oil seeds. This movement is increasing for sorghum. In the same time the prices of all crops and livestock outputs keep a high value reflecting high demand and scarcity of goods. Presently the high demand level is accentuated by the decrease of average yields that cannot offset the increase of cultivated areas. Marketing and export of main agricultural commodities can be particularly hampered by limited support to infrastructure, whether for export or for local markets.

It's urgent now to improve commodities in domestic market through removal of technical, financial, marketing and legislative items. In this general context all product can find a good outlet on local markets and also to export. But the high local demand conducts to favour domestic markets and specifically the neighbor transaction spots, keeping in mind the attractive potential of project area toward surrounding population severely suffering from the lack of water. In the presentation of cropping pattern the analysis emphasizes on the capacity of farmers to develop traditional crops, principally sorghum, groundnuts, sesame, sunflower and vegetables, amongst them sweet potato and salads insuring a high revenue. The such cropping pattern is in line with the local population needs, and more over it allows them to win the best revenue with crops very much in demand, and also with good price level on the markets. The two main conditions (volumes to sold, and good level of prices) to tackle the market are here gathered.

In this context the level of forecasted price is reasonably ambitious and certainly not over estimated for the long term. The strong elevation for cereal prices registered during the first half of 2008 was considered as an extreme value, all the more so since the level stays little bit below. All prices are expressed as farm gate prices. The values applied come from investigation in the field during December 2009. The price used can be applied in the same condition along a production year.

An average price is better significant than a price following the market fluctuations with more or less unexpected variations. The identification of food requirements for local population allows approaching a production volume available to sell on neighbor village markets, and after satisfaction of this first market level, towards bigger Sudanese cities. The calculation of local food requirement is made on the base of FAO survey following the annual family consumption. The calculation is made in equivalent kg of cereals on the basis of 192 kg per capita per year. The precise break down figures are 141 kg for cereals, 13 kg for pulses, and 9 kg for oil seeds. It is possible to consider these needs as a minimum. 35 000 inhabitants would be present in project area in 2016.

[5] The balance of trade in agriculture was negative for many years due to increasing imports of food and other agricultural related items.

Table 7.2: Farm gate prices in financial value

WAD MESKEEN IRRIGATION PROJECT		
Farm gate price		Financial value
		SDG / qt
	Sorghum	62.5
	Groundnuts	137.5
	Sesame	237.5
	Sunflower	100.0
	Okra	100.0
	Okra export	200.0
	Melon	78.0
	Melon export	130.0
	Cucumber	32.5
	Sweet potato	70.0
	Water melon	17.9
	Rocket	80.0
	Jewsmallow	25.0
	Purslane	364.5

Table 7.3: Share out for outputs

WAD MESKEEN IRRIGATION PROJECT							
Pilot farm	Cropping Pattern	Cropping Pattern	Usable yields 4th Y	Total Production qt	Food requirements	Food requirements 35 000 People	Gross tradable production
7 500.0 ha	%	ha	qt/ha	7500 ha	c/Y	qt	qt
Sorghum	33.3%	2 497.5	30.6	76 423.5	141 kg	49 350.0	27 073.5
Groundnuts	33.3%	2 497.5	30.6	76 423.5	13 kg	4 550.0	71 873.5
Sesame	7.1%	532.5	18.0	9 585.0	13 kg	4 550.0	5 035.0
Sunflower	7.1%	532.5	16.2	8 626.5	9 kg	3 150.0	5 476.5
Vegetables	14.2%	1 065.0	260.2	277 083.2	25 kg	8 750.0	268 333.2
Forest tree	5.0%	375.0					
Total	100.0%	7 500		448 141.7		70 350.0	377 791.7

The assumptions about local population inside the irrigation perimeter are:

- 30,000 inhabitants in 2009, gathered in main city of Hawatta at the extremity north west of project area.
- 1,000 inhabitants sparing over the area in little villages.
- Natural growth rate 2.1% (US aid 2008 Population Reference Bureau for Sudan).
- Annual immigration rate -0.0% for this rural area (1% for urban areas). The rural exodus is one of main characteristics of the demographic situation in this area. In the irrigated schemes as well as in the mechanized areas, the country relies on migrant labour for planting and harvesting of main crops. Young people prefer leave the rural area to the town to seek employment in the growing service and industrial sectors.

With the project, the tradable volume available at national level, reaches about 2700 tons of cereals. That means less than 1% of the national production. For pulses the tradable production represents also less 1% and for oil seeds 2.3% of national production. That means in other words a weak impact on the national market and probably on the level prices in return.

Table 7.4: National production for main crops

In thousand metric tons	2007	2008	Tradable production for Project area	% /2009
Sorghum	4,999	3,869	2.7	0.1%
Groundnuts	564	716	7.2	1.0%
Sesame	242	350	5.0	1.4%
Sunflower	73	100	5.5	5.5%

Source: Central Bank of Sudan 48th annual report

7.2.2 Crops

The forest sector also provides about 87% of the power needs of the population in addition to 7% of the industrial timber need.

7.2.3 Livestock and Livestock Products

The livestock is mainly a provider of meat but fails to produce adequate amount of milk. Milk production is estimated at 7.5 million tons and hence big amounts of powder milk are imported. This situation is likely to continue for some time.

7.2.4 Credit Facilities

Availability of micro finance is limited, and the bank credit supply to the agricultural sector, in relative weight, had been declining compared to the total credit supplied to all the sectors. One of the reasons put forth by the Bank of Sudan is that weak absorptive capacity of the agricultural sector does not allow it to utilize all the allocated credit thus depriving the other sectors from obtaining a fair share of that total allocated credit. Therefore, the Bank of Sudan began reforming the credit policy in favour of the sectors with the greater absorptive capacities. The Bank wants to be able to respond to the main needs, generally required by the farmers in term of advances and short credit for seeds, labor, and agronomic inputs.

The proposed green mobilization program is a wide ranging objective including a most important amount to the agricultural sector. Agricultural credit should be used as a tool to assist farmers interested in adopting modern irrigation technology and associated cropping systems based on high value crops. The aim of annual program would encourage the stability of the rural people and reduce the pace of rural-urban migration taking place in the country.

8. SOCIAL AND ENVIRONMENTAL IMPLICATIONS

8.1 PUBLIC PARTICIPATION AND SOCIAL IMPLICATIONS

8.1.1 Target Groups

The surveys revealed the village characteristics in which parameters like establishment of the approximate population and the tribes living in the villages are found. Apparently, these villages were established long some time ago. Some of them like Hilat Khalifa have been established during Mahdia era. The recent one is Ingamaina, but also dated back to early seventies. This means that, the people have created a way of life suiting their surrounding environment and typically representing the rural traditional and peasant communities. Nonetheless, there are semi-nomads like Awlaad Saeed tribe in Kumor Basheer. On the other hand, some villages are densely populated like Hilat Khalifa, Bazora Khalifa, Wad Abakar, Maykankana, Abdel Lateef and Kumor Basheer. Concerning the tribes living in the area, it is very rare that a single tribe is dominating the village with only exception in Maykankana in which Hawsa is the sole tribe. All other villages are inhabited by different tribes. In some cases eight or more tribes are found in one village. It is worthwhile to mention that, although these tribes have different ethnical and cultural background, they have developed their own mechanism that helps to promote peace and/or to mitigate conflict among them.

8.1.2 Gender Aspects

Women occupy a very low status in the society. They are totally excluded to domestic services and agriculture. Their needs are not considered by the village community. Very limited education facilities are available to women. In village like Makankana which inhabited by Hawsa tribe, no single girl attended school. The only available education facility for women in this village is Khalwa. In other villages, girl education does not go beyond basic level education. Women after marriage are totally under the control of the husband. The husband takes all decisions regarding the household. Women participation in village decision making is not allowed, because this is the men domain. Owning land is also men's domain despite their participation in farming activities.

8.1.3 Resettlement Aspects

The project entails development of supplementary irrigated agricultural scheme in an area of about 7,500 ha along the Rahad River. The project may also provide community infrastructure and provision of community services. To establish the agricultural project requires land acquisition without any displacement of the villages or settlements in the project area. However, the legal framework of the land held by the local inhabitants in the area is organized by customary and traditional rules and regulations where rights less than full ownerships are recognized. Hence, in the area two types of land tenure are found. The most widespread is customary tenure where areas are granted to individuals through tribal leadership (Sheikhs) and lease or license given by the government to some individuals to utilize areas between 500-1000 Feddans for limited number of years when the lease is either renewed or withdrawn. The unclaimed land is left as rangeland or may be allotted to migrants by Sheikh.

According to Sudan's Interim Constitution (2005), the customary rules are to be respected in any development activity. Land needed for public use may be taken by government and the claimants (owner) must be compensated in any form, Land for Land or Cash. The procedure for land acquisition according to 1925 Land Act involves the following:

1 Announcement of intention to take land for the project in any media that reaches the local inhabitants.

2 Appointment of Resettlement and Registration Officer.

3 Appointment of a committee composed of :

- Representative of Survey Department in locality
- Local Government officer
- Land Registration Officer of the locality
- Local leaders
- Representative of impacted persons

The committee hears the claims and if convinced, registers the land in the name of the claimant. The committee is also required to set aside land areas as village reserves. The above mentioned steps require the identification of villagers claiming rain-fed agricultural land held through customary procedures or lease and then the committee agrees on the appropriate compensation mainly land for agriculture in the new project. In the process of compensation, it is hoped that the committee gives due consideration to vulnerable groups such as female-headed households and the aged for whom the loss of land could lead to further hardships. Hence, resettlement in the project area does not require displacement of villagers or removal of villages. It may require some planning if the locality deems it necessary. Most of the activities will be confined in identifying individuals claiming agricultural land that becomes part of the project and the land Registration Committee agrees on appropriate compensation procedure, mainly Land for Land.

For smooth land acquisition for project, the following are recommended.

1 Involvement of local leadership (Sheikhs, Omdas, Shoora Committees etc.).

2 Pay attention to customary land tenure regulations.

3 Pay attention to nomadic usufruct rights and provide corridors for nomadic livestock to cross to the River.

4 Give attention to vulnerable groups.

8.1.4 Land Tenure Aspects

The situation regarding land tenure in the Wad Miskeen study area is complex. Basically, there is no freehold land; the ultimate title of the land is vested in the state. People who farm or control this land have one or more of the following three systems of tenure over the land.

Leasehold This refers mainly to SMRF leased land (if it occurs in the study area) and any 'Semi-traditional' rainfed land for which leases have been issued.

Usufruct This relates to the traditional rights of people to farm in specific areas and includes 'Traditional Landholdings' close to the River.

Easement This refers to the rights of nomads where they have traditionally benefited from their historical right to move across certain areas and obtain grazing and water.

Leasehold land has conditions attached although these may well not be adhered to. Leases have to be renewed annually in Gadarif at a current cost of SDP 3,000. Areas of any 'Semi-traditional' rainfed land for which leases have been issued can also be assumed to be leasehold but similar land for which leases have not been issued must be assumed to be covered by usufruct rights only. Usufruct land includes all the traditional 1-50 feddan bildat farmers and all the riparian communities along the Rahad River. Many of the farmers in this category are under pressure from undemarcated mechanised farming. Nomadic communities claim that they have ancient rights over land along the Rahad River as their summer grazing land and also claim rights over the traditional northeast-southwest aligned stock movement routes that they have been using for many years. They also insist on access to water.

In addition to these land tenure categories above, there are also areas of forest land within the study area that are owned by the state and managed by the National Forests Corporation. These forests have some degree of protection (the felling of trees is prohibited) although grazing is practiced within them. Whether any of these forest areas fall within the traditional stock migration routes or whether they comprised traditional grazing areas before being designated and protected as forest areas, is not known.

The Southern Kassala Agricultural Development Project (SKAP) noted that the area along the Rahad River was considered to come under **'Traditional Landholding'** where agriculture is practised at subsistence level with some cash generated from sesame and fruit and vegetable production and possibly some paid employment. Farmers in this category hold small plots of land (1-50 feddan).

The salient features of these communities are:

- The villages designated are ancient and the villagers have been cultivating their land for a very long time.
- The security of individual tenure of land immediately adjacent to the River (geruf) is further reinforced and symbolised by ageing mango and lime orchards which, in some cases are, irrigated by River-pumps
- The villagers grow rainfed sorghum and sesame on land by the River starting immediately behind the village settlements. These lands (bildat) have likewise been under cultivation for a long time
- Had they applied to register their land before 6th April 1970 the majority of these villagers could have qualified as freeholders

The study also indicated that away from the River a hybrid landholding regime with characteristics of both the traditional and large-scale existed. It called this a **'Semi-Traditional Landholding'** regime. Land users in this category were able to multiply their original holdings through purchase of land. A farmer in this category holds a total area of 100-1,000 feddans, usually composed of separately dispersed smaller plots. The salient points of this category are:

- Land tenure in this category is fraught with legal intricacies
- Assuming that the seller has a valid usufructuary title, the sale of land, the bare ownership of which belongs to the State is not self-evidently legal
- If one or more of the plots purchased are situated within the land of a village other than that of the purchaser, the communal usufruct rights of the village may prevail over the private interest of the purchaser.

- Information regarding the land tenure status of the study area was obtained through a socio-economic survey. This concentrated on ten villages along the Rahad River and included two types of questionnaires, observations and group discussion.

Table 8.1 reveals the land tenure status of the respondents. Most people (in 8 out of 10 villages) who 'own' (in reality have usufructory rights) land have inherited it. The second most common means of acquiring land (in 5 out of 10 villages) is through buying land closely followed (in 4 out of 10 villages) by being given land by the sheikh. The range of holding size is diverse ranging from five to a thousand feddan, generally with smaller plots close to the River and larger areas further away. The larger holdings are owned by few people.

Customary tenure is prevailing but some original inhabitants own large plots while recent migrants rent land for cultivation.

Table 8.1: Land tenure and range of holding size

Village	Agricultural land			Hired	Range of holding size (feddan)
	Inherited	Bought	Given by Sheikh		
Bazora Kahlifa	√	√		√	5 – 15
Hilat Khalifa	√	√			25 – 500
Ingamaina			√		5 – 50
Kumor Basheer	√	√			10 – 15
Wad Batool Mokharim	√				20 – 1000
Wad Batool Hilat Bakheet	√				Not indicated
Shamam	√				15 – 500
Wad Abakar	√	√	√		10 – 1000
Abdel Lateef			√		Not indicated
Maykankana	√	√	√		5 – 10

Source: Field Survey July 2009

Additional information indicated that around Hawata the land tenure situation was stable with most farmers having leases and with smaller irrigated plots of land closer to the River (average 3 fd) and larger rainfed plots further away (average 5fd but large variation). It was also stated that there was no conflict between farmers and pastoralists. In the south of the study area a different picture emerged, still with smaller irrigated plots of land close to the River and larger rainfed parcels further away but with more conflict between pastoralists and farmers. There are four or five traditional livestock migration routes passing through the area used by nomadic pastoralists who bring their animals to water in eleven pools on the right bank of the River. According to local sources these routes (which are not well defined) have shrunk from 150m wide to 50m wide through encroachment by rainfed farmers who complain of livestock harming their land and soil.

In addition there is pressure for land on smaller farmers close to the River from larger mechanised farmers.

In Bazura, at the very south of the study area, people indicated that only very few people had leases but that some irrigators owned land close to the River, people on SMRF land well away from the River had leases but that people in the rainfed land (presumably corresponding to the SKAP semi-traditional landholding) did not have leases. They also indicated that the government was in the process of registering land.

In summary, the situation regarding land tenure in the study area is complex. The problems associated with land tenure are not a major constraint to agricultural production in the study area but are a source of rising social conflict and will need clarification before the proposed irrigation scheme is implemented. As noted in the SKAP in 1992 'the whole area of land allocation, registration, demarcation, and land use rights is fraught with confusion, contradictory laws and regulations, and disparate records …… the roles of many GoS institutions remain unclear and lines of authority and overall responsibilities are ill-defined'. Unfortunately the situation does not appear to have changed much by 2009. The complexity of the land tenure in the study area and the issues of conflict between rainfed farmers, irrigators and nomadic pastoralists mean that there are a number of issues to be resolved and measures to be taken for the successful implementation of the irrigation project.

Need for a land audit

Given the complexity of the land tenure situation with Traditional Landholdings, Semi-traditional Landholdings, SMRF land (all either with or without leases), Forests and Livestock Migration Routes it is considered essential that a Land Audit be undertaken prior to any irrigation development. Even if the proposed irrigation scheme does not include land reallocation (and certainly if it does) then a land audit will be needed to clarify the land tenure, land use and land management arrangements.

Need to redefine livestock migration routes

The main source of conflict in the study area is between farmers and nomadic pastoralists. According to the pastoralists the routes have been encroached upon by farmland and according to farmers the pastoralists' animals encroach on their land. There is therefore a need to redefine these routes and for both sides to agree on their location and the land management conditions that will apply.

Requirement for 5% forested area

According to regulations, there is a requirement that any irrigation development must set aside 5% of the area for forests. Given that Wad Miskeen is crossed by livestock migration routes and that there is an additional requirement for fodder it is proposed that this 5% forested land be composed of multi-purpose tree and shrub species that could provide fodder. If possible these trees could help to better define the migration routes.

Land Management in Forest Areas

There is a need to define the criteria for land management in the forest areas that already exist in the study area. It is known that the Forests Act of 1989 changed the classification of many pasture areas to forest (UNDP 2006a) but also made any existing pastoral usufruct rights subject to the restrictions contained in the Forests Act.

The Forests and Renewable Natural Resources Bill of 2002 is a federal initiative to synchronize access to pastoral resources with forest management but it is not known what the current status is with regard to forest management in the study area. This should be clarified prior to irrigation development.

8.2 ENVIRONMENTAL IMPACT ASSESSMENT

8.2.1 Terms of Reference

The Terms of Reference for the Environmental and Social Impact Assessment of the Wad Miskin Study were given in the ENIDS contract between BRL and ENTRO, and stated that:

"Irrigation and drainage schemes, whether large or small-scale, are likely to generate impacts that can have significant effects on the immediate and off-site environments, and these may range from soil erosion and sedimentation, to an increase in the prevalence of vector-borne diseases, especially malaria, guinea worm. The Consultant will undertake an environmental impact assessment, in line with African Development Bank guidelines.

These will include assessments of the institutions responsible for the resettlement of affected population and make recommendations for their improvement. The study also, will include collection and analysis of environmental baseline data, identification of impacts (both positive and negative) and their evaluation, design of mitigating measures, and an environmental management and monitoring plan. The particular issues that are to be addressed will include but not be limited to:

- Soil erosion and sedimentation in the catchment area of the project;
- Flooding and water-logging;
- Water-borne diseases (malaria, schistosomiasis, bilharzia and others);
- Fertilizer and pesticide application;
- Effects on quality of water in downstream receptors;
- Re-settlement of affected population;
- Transboundary impacts.

"The Environmental Impact Assessment studies would cover the downstream countries as well as the project areas. The Social value of irrigation development in terms of mitigating the negative effects of drought such as loss of human and animal life would be discussed, and the Consultant will provide a methodology on how to quantify in monitoring terms the social benefits that can be accrued from irrigation development like curtailing movement of refugees around the border areas. The study will identify the relevant natural resources, the eco-system and the population likely to be affected. Direct and indirect impacts will be identified and any particularly vulnerable groups or species highlighted. In some instances views will be subjective and the Consultant will give an indication of the degree of risk or confidence and the assumptions on which conclusions have been drawn.

"The output required will be a report examining the existing environment, the impacts of the proposed project on the environment and the affects of the environment on the project, both positive and negative, the mitigating measures to be taken and any actions needed. Interim reports, for example of baseline studies, will be phased to be of maximum value to parallel technical and economic studies.

"Baseline data collection, if needed, can be time consuming and will have a major impact on the cost and time needed for the study. If considerable data exists, for example a good record of water quality information and hydrological statistics, the EIA may be possible without further primary data collection. If data are scarce, time must be allowed for field measurement and analysis. In any event, reference would be made to publications such as the ADB guidelines (available at the Bank website) and World Bank Operational Directive 4.01 (1991). The format will be designed to suit the national and transboundary aspects. The Consultant will focus on the major issues and the most serious likely impacts, opportunities for enhancing any positive benefits from the project should also be highlighted."

8.2.2 ADB Environmental Assessment Category

The assessment of impacts made in this study have concluded that the proposed project would be deemed as a Category 2 Project in the African Development Bank's environmental assessment procedures, for which an environmental and social assessment is required. In this category, there would be impacts but they would be less diverse than Category I. Category 2 states:

'Category 2 projects require the development of an Environmental and Social Management Plan (ESMP). These projects are likely to have detrimental and site specific environmental and/or social impacts that are less adverse than those of Category 1 projects and that can be minimized by the application of mitigation measures or the incorporation of internationally recognised design criteria and standards'.

As has been emphasized throughout all Feasibility Study reports and annexes of the Wad Meskin Agricultural Development Project (WADP), this development of the project would be a major undertaking which cannot be limited to constructing the irrigation infrastructure, while underrating the necessary social, economical, institutional and policy framework. Paying attention to the social and environmental conditions alongside with the technical engineering can not only greatly enhance the benefits of the project for the population, but is actually crucial for its success. The results of the environmental and social impact assessment are discussed in full in Annex 10 and its supporting Appendix. Table 8.1 provides an overview of the impacts and is based on the International Commission for Irrigation and Drainage (ICID) checklist (Doughtery and Wall, 1995; Mock and Boulton, 1993).

8.2.3 The ESIA Studies

The environmental studies, which have involved two environmental specialists - one Sudanese for 1 mm, and one international for three weeks, have utilised the baseline surveys made for soils, social studies, topography, agriculture, livestock, and geotechnical works. It was not possible to commission any further studies, since there was no provision in the project costs for additional staff and time. The study area was visited during the dry and wet seasons of 2008-2009, pre- and post-harvest, to gauge the status of the natural vegetation, land use practices and assess the crop calendar.

In the Environmental Annex where it is not clear that we have the data to close on a particular issue we say so. This is usually because we did not have the personnel or time resources to make detailed assessments of, for example, faunal and floral ecology including *maya* lakes, archaeology, nomadic movements.

These need to be included in a detailed programme of assessment at the time of detailed design. All these types of surveys would each take several months work by various specialists. Both dry and wet season surveys are needed, and for fauna night-time surveys are important as much of the smaller mammals are nocturnal. The FS had no budget or time allocation for such surveys, interesting and essential as they might be, and we have made the best of the available data and our own extensive field surveys.

8.2.4 Methods

The methods used in the environmental impact assessment (EIA) of the Wad Miskin project follow the procedure given in the ToR, with reference to EIA guidelines of the AfDB, the World Bank Operational Directive 4.01 (1991), and Sudan Environment Protection Act. The environmental work has made full use of other annexes in the project, and examined numerous research papers, documents and reports on the area. It has not though had official access to a parallel study being made for the Kenana-Rahad Irrigation Projects by the Dams Implementation Unit (DIU).

The EIA describes the biophysical and social environments of the study are, and relates identified environmental impacts with proposed mitigation measures, where these are necessary, so as to ensure that the project proposals and design plans are compliant, and in accord, with the AfDB and Sudanese environmental assessment procedures and requirements.

The principal purpose of an irrigation project is to increase agricultural food production, usually in an area where rainfed cropping is difficult or impossible as rainfall is deficient, insufficient or irregular, and there is a high risk of crop failure: in 2009 in the Wad Miskin and adjacent lands, very large areas of rainfed sorghum have totally withered as the rains started and then stopped. In this case irrigation water could have supplemented the rainfall and allowed a harvest. The potential of the proposed project therefore for food security amongst the local population and region is strong.

Other positive environmental and social impacts resulting from irrigation development include higher crop yields; and higher cropping intensities with multiple cropping; poverty reduction and reduction in malnutrition; the elevation of farm outputs and higher farm incomes; creation of employment possibilities on the farm and other infrastructural activities.

Land use changes effected by irrigation development will also impact on the bio-physical environments, and all or part of forests and woodland, rangeland and pasture, flora and fauna can be lost. The social impact from the forced displacement of, for example, farmers and nomads already in an area is one such issue that requires careful assessment of existing land use practices. The land tenure studies of the FS examine the existing land use patterns and rights, so that all potentially project-affected populations are indentified.

Water abstraction from rivers and agrochemical or industrial waste laden polluted return flows can cause further impacts on water users, biota and habitats, and there are threats also to near surface or deep aquifers, who may be extracted at locations remote from the project. Disease vectors can be enhanced by irrigation infrastructure, but the delivery of water to lands previously water-short areas, that improves human settlement and livestock are positive impacts. A recent study on pollutants in the Nile by Mostafa El-Sheekh (2009) noted that few studies have been made in Sudan.

Negative impacts of the bio-physical environments though can be common, and have the capability to wreck a project before it is off the ground. Sufficient care must be taken to plan a project, and a successful project plan will need to make a balance of the contrasting impacts: the ICID checklist, with its supporting guidelines, ensures that these issues are thoroughly examined in a step-by-step procedure.

The key tasks of the environmental impact assessment studies are to assess any potential positive and negative impacts that may arise from the implementation of the Project in a manner that facilitates the comparison between available project alternatives. These involve screening and scoping of impacts, the identification of mitigation measures, and proposals for environmental management.

For the Wad Miskin Feasibility Study Baseline studies were made of soils and geomorphology, land use and land cover, water resources, groundwater, socio-economics, livestock, land tenure, agricultural production, and topography. The environmental studies made full use of these assessments and made checks in the field.

8.2.5 Main impacts

The assessment of impacts made has shown that both positive and negative impacts could be likely as a result of project implementation. For some impact categories it is not possible to determine at this stage what the outcome would be. Also, the scale of the negative impacts cannot be defined exactly at this time in a feasibility study, as these will depend on the proposals for a final detailed design for the project. During detailed design the ESIA impacts, proposed mitigation measures and the EMP should be reviewed, brought up to date and costed. These measures would then be incorporated into the final engineering designs, the tenders, the client's and consulting engineer's tender supervision, and made available too to other agencies concerned with implementation.

The major changes caused by the project will be a change of land use, due to the creation of new agro-ecosystems and changes to existing ones. Land take will be necessary where project constructions of canals, weirs, barrages, and various other constructions for maintenance, fuel storage, settlements and administration. New water bodies may form and the ecology of existing ones (*maya* and river courses) could be affected adversely by agrochemicals. All these have the possibility to cause negative physical and social impacts if not the subject of careful project planning and implementation.

The creation of irrigated farming areas will greatly increase the biological activity and production, and biodiversity will be increased in the irrigated areas, with likely creation of new habitats that could impact on existing ecosystems, such as rats. Mitigation will be in the form of an Integrated Pest Management (IPM) programme that the project will need to establish in collaboration with the Ministry of Agriculture (Gedaref State) and with the technical advice given out by the Agricultural Research Corporation (ARC).

The proximity of proposed project works to the Dinder National Park poses serious questions on impact to DNP fauna and flora wildlife. There is a limited knowledge on movements of wildlife outside the park and conflicts with pastoralists gained from interviews with park officials and local communities. The project could lead to both positive and negative impacts on wildlife. The canal and weir located just within the DNP could obstruct the passage of wild animals, but it is technically possible to incorporate access structures into the design of the canals that provide access for wild animals to the water surface in the canal. The usefulness of such structures depends on appropriate siting also, and these would need to be established during the next phase of detailed design, when a more detailed assessment of wildlife movements may be needed, probably over a whole year. At that time additional consultations with local people will help identify wildlife movements in the area, and ensure that locations of structures would be such that they do not impede wildlife from access to traditional water sites.

The main sensitive areas where barrage implementation would impact on natural or semi-natural habitats are along the two river banks of the Dinder and Rahad. The tender design is expected to minimize the local impacts by possibly avoiding the loss of valuable bank vegetation, in particular larger trees and shrubs, and especially where those have a stabilizing function for erodible banks. Unavoidable losses can be compensated by replanting of trees and shrubs after the construction phase. The EMP, utilising the experience of the FNC in Hawata will specify where these should be and the appropriate species to be adopted: these should be indigenous species in any case.

Table 8.2: Results of impact assessment for Wad Meskin

For each environmental effect a cross (x) is placed in one or more of the columns:		Positive impact very likely	Positive impact possible	No impact likely	negative impact possible	Negative impact very likely	No judgment possible at present
Report section	Impact Category:	A	B	C	D	E	F
4.1 Hydrology	Low flow regime						X
	Flood regime		X		X	X	
	Operation of dams		X		X		
	Fall of water table			X	X		
	Rise of water table			X			
4.2 Organic & Inorganic Pollution	Solute dispersion						X
	Toxic substances				X		
	Organic pollution				X		
	Anaerobic effects				X		
	Gas emissions				X		
4.3 Soils and Salinity	Soil salinity				X		
	Soil properties		X		X		
	Saline groundwater				X		
	Saline drainage				X		
	Saline intrusion			X			
4.4 Erosion and Sedimentation	Local erosion				X		
	Hinterland effect				X		
	River morphology		X		X		
	Channel structures				X		
	Sedimentation		X			X	
	Estuary erosion			X			
4.5 Biological & Ecological Change	Project lands -a-Land take:		X			X	
	-b-Provision of irrigation		X		X		
	-c- Settlement development				X		
	Water bodies		X		X		
	Surrounding area		X		X		X
	Rivers & riverine habitats				X		X
	Rare species		X		X		X
	Animal migration		X		X		
	Natural industry		X		X		X
4.6 Socio-economics	Population change		X		X		X
	Income & amenity	X			X		X
	Human migration	X			X		X
	Resettlement		X		X		X
	Women's role		X		X		X
	Minority groups				X		X
	Sites of value						X
	Regional effects				X		X
	User involvement		X		X		X
	Recreation		X		X		X
4.7 Health	Water & sanitation	X			X		X
	Habitation	X				X	X
	Health services		X		X		X
	Nutrition		X		X		X
	Relocation effect						X
	Disease ecology					X	
	Disease hosts					X	
	Disease control					X	X
	Other hazards				X		
4.8 Ecological Imbalances	Pests & weeds		X		X		
	Animal diseases		X		X		
	Aquatic weeds					X	
	Structural damage			X			
	Animal imbalances						X

Source: ICID Checklist Methods

Within the irrigation scheme, access to the canals may also be required for domestic purposes, and it will be necessary to specify the access locations (steps and / or ramps) in the tender design phase. This should be based on consultations with nearby communities, and on planning for any new settlements (as yet not identified in the planning process).

The occurrence of aquatic weed problems cannot be ruled out in any part of the project. Further areas of concern, as experienced elsewhere, would be the areas at the tail ends of gravity irrigation schemes, where frequent over – irrigation could lead to stagnant water in field canals and drains. The drains, increased nutrient content of the water due to fertilizer application can enhance the weed growth. In a small scheme such as Wad Miskin these issues should be controllable by the project management.

The project is likely to impact on the passage and traditional grazing habits of nomadic groups. The latter with their extensive livestock herds already play a vital part of the local rural economy of Hawata and Mufaza and their hinterlands, as well as the Sudan meat economy (see Annex 6). The project must ensure that traditional rights of way are not impeded, and that provision of grazing lands and forage production are accommodated in the project development plan. The irrigation design has provided for various stock routes that lead from the Rahad River, the water source, out to the plains, the grazing source. But these routes need to be finalised in consultation with, and participation of, all stakeholders. The project can also develop irrigated fodder resources that pastoralists can buy, as in other areas.

8.2.6 Transboundary Impacts

The impact of a project across a border on another country can have deleterious effects if possible impacts are not examined during project planning. A study on transboundary environmental analysis by NBI et al (2001) identified several issues that relate to the Nile basin:

- Physical or chemical impacts that can cross national boundaries downstream;
- Loss of degradation of wetlands and lakes;
- Need for transboundary cooperation to protect key habitats;
- Lack of early warning systems;
- Spread of exotic and invasive water weeds;
- Waterborne diseases (malaria, diarrhoea, bilharzia).

The report noted that a protected area of 500,000 ha lies between the Dinder and Rahad Rivers on meandering floodplains and is important for wildlife grazing and migratory birds but is affected by poaching, firewood collection, illegal grazing. This area, termed a Significant Wetland, is actually the more undulating lands of the Dinder National Park, and the subject of a GEF/UNDP funded management plan in 2004.

The DNP might be affected by any future water resource developments in the catchment of the Dinder, within Ethiopia. The Blue Nile Basin studies in the 1960s proposed an irrigation project in Ethiopia along the border with Sudan but no further surveys were made and it appears to have been a somewhat speculative assessment. At present nothing is planned and further into Ethiopia the upper waters are remote with poor access and steep slopes unsuitable for agricultural development.

The Wad Miskin area lies well within Sudan and is some 150 km, and at a much lower elevation from the Ethiopian border. It is remote from the Egyptian border far to the north. The WAD MISKIN project (Phase I) will take 10 % off the peak flow from the Rahad River, and 0 % from the Dinder. The impact of this reduced flow into the Nile is considered by the project to be minimal. In the second phase of the project, that would be for 100,000 ha of supplementary irrigation in the Rahad II area, 10% would be taken from the Rahad peak flow and max 80% of the Dinder peak flow. The downtream impacts of this on the fishing, water supply for livestock and villages, small scale irrigation, and other livelihoods along the Dinder River are likely to be significant.

Transboundary impacts are, therefore, not considered relevant in this context at this time, but any future development in Ethiopia should be careful monitored. Regulation of the Dinder River by a dam in the upper catchment could actually improve the seasonality of water supply and flow downstream, but no studies have been made to see if such an undertaking is feasible.

8.2.7 Mitigation Planning

The assessment of impacts has shown that both positive and negative impacts could be likely as a result of project implementation. For some impact categories it is not possible to determine at this stage what the outcome would be. Also, the scale of the negative impacts cannot be defined exactly at this time in a feasibility study, as these will depend on the proposals for a final detailed design for the project. During detailed design the ESIA impacts, proposed mitigation measures and the EMP should be reviewed, brought up to date and costed. These measures would then be incorporated into the final engineering designs, the tenders, the client's and consulting engineer's tender supervision, and made available too to other agencies concerned with implementation.

The major changes caused by the project will be a change of land use, due to the creation of new agro-ecosystems and changes to existing ones. Land take will be necessary where project constructions of canals, weirs, barrages, and various other constructions for maintenance, fuel storage, settlements and administration. New water bodies may from and the ecology of existing ones (maya and River courses) could be affected adversely by agrochemicals. All these have the possibility to cause negative physical and social impacts if not the subject of careful project planning and implementation.

The creation of irrigated farming areas will greatly increase the biological activity and production, and biodiversity will be increased in the irrigated areas, with likely creation of new habitats that could impact on existing ecosystems. The crop production will also attract and could lead to vulnerability to attack by crop pest populations such as rats, qualea, Wad Abrag (sparrow) and insects. The existing relict woodlands and project driven shelterbelts will offer suitable sites for bird breeding and roosting. Field rats may become a problem, and experience from Rahad, Gezira and other irrigated schemes has shown that rats in general, and the Nile Rat (Arvicanthus niloticus) in particular, can establish themselves very quickly as a serious crop pest wherever food, water and shelter would be readily available throughout the year. Mitigation will be in the form of an Integrated Pest Management (IPM) programme that the project will need to establish in collaboration with the Ministry of Agriculture (Gadarif State) and with the technical advice given out by the Agricultural Research Corporation (ARC).

The proximity of proposed project works to the Dinder National Park poses serious questions on impact to DNP fauna and flora wildlife. There is a limited knowledge on movements of wildlife outside the park and conflicts with pastoralists gained from interviews with park officials and local communities. The project could lead to both positive and negative impacts on wildlife. The canal and weir located just within the DNP could obstruct the passage of wild animals, but it is technically possible to incorporate access structures into the design of the canals that provide access for wild animals to the water surface in the canal. The usefulness of such structures depends on appropriate sitting also, and these would need to be established during the next phase of detailed design, when a more detailed assessment of wildlife movements may be needed, probably over a whole year. At that time additional consultations with local people will help identify wildlife movements in the area, and ensure that locations of structures would be such that they do not impede wildlife from access to traditional water sites.

The main sensitive areas where barrage implementation would impact on natural or semi-natural habitats are along the two river banks of the Dinder and Rahad. The tender design is expected to minimize the local impacts by possibly avoiding the loss of valuable bank vegetation, in particular larger trees and shrubs, and especially where those have a stabilizing function for erodible banks. Unavoidable losses can be compensated by replanting of trees and shrubs after the construction phase. The EMP, utilising the experience of the FNC in Hawata will specify where these should be and the appropriate species to be adopted: these should be indigenous species in any case.

Within the irrigation scheme, access to the canals may also be required for domestic purposes, and it will be necessary to specify the access locations (steps and / or ramps) in the tender design phase. This should be based on consultations with nearby communities, and on planning for any new settlements (as yet not identified in the planning process). The occurrence of aquatic weed problems cannot be ruled out in any part of the project.

Further areas of concern, as experienced elsewhere, would be the areas at the tail ends of gravity irrigation schemes, where frequent over – irrigation could lead to stagnant water in field canals and drains. The drains, increased nutrient content of the water due to fertilizer application can enhance the weed growth. In a small scheme such as Wad Miskin these issues should be controllable by the project management.

The project is likely to impact on the passage and traditional grazing habits of nomadic groups. The latter with their extensive livestock herds already play a vital part of the local rural economy of Hawata and Mufaza and their hinterlands, as well as the Sudan meat economy (see Annex 6). The project must ensure that traditional rights of way are not impeded, and that provision of grazing lands and forage production are accommodated in the project development plan. The irrigation design has provided for various stock routes that lead from the Rahad River, the water source, out to the plains, the grazing source. But these routes need to be finalised in consultation with, and participation of, all stakeholders. The project can also develop irrigated fodder resources that pastoralists can buy, as in other areas. The key monitoring issue will be to avoid negative impacts of polluted drainage water on natural water bodies or on water uses for domestic purposes, canal and drainage water by regular monitoring. There is a risk of groundwater pollution from intrusion of agrochemicals into the shallow groundwater aquifers. These are used for drinking water supply in many locations. It is necessary to monitor regularly the groundwater quality in order to detect any such impacts. Parameter should include pH, TDS, Nitrate, P04, BoD, coliform bacteria, and pesticide residues.

Based on the final design, further areas where protection or compensation measures are to be established have to be specified. This will include:-

- Areas disturbed during construction that need to be re-planted with trees and shrubs to protect river bank from erosion.
- Safety provision at canal crossings at places where canals are used for domestic and wildlife purposes, and in regular intervals along the canals.
- Safe design for structures and equipment for storage and handling of water-endangering and hazardous substance (e.g. fuel storage, fertilizer and pesticide storages).
- Wastewater from all construction sites shall not be allowed to be discharged uncontrolled over land on into surface water drains or rivers.
- To control aquatic weeds in the irrigation canals biological control is recommended

The mitigation measures that are recommended to be taken further during detailed project planning and then in implementation are shown in Table 8.2. These are recommended in order to ensure that the environmental and social risks identified in the environmental impact assessment are properly addressed. If they are not then the project will fail in its duty to protect and sustain the environment.

Table 8.3: Mitigation Measures

	Impact	**Mitigation Measures**	**Institutional Bodies Responsible**
Water	Water losses	Downstream controlled water distribution systems.	Ministry of Irrigation and Water Resources
	Risks of spillage and flooding	To minimize the risks from uncontrolled spillage and subsequent flooding, the design will include escape to evacuate such excess water safely.	Min. Irrigation and Water Resources (MIWR)
	Waste water from all construction sites should not be allowed to be discharged uncontrolled over land on into surface water drains or rivers	Routing waste water through settling ponds, and control of pH.	MIWR / contractor
	Water pollution from drainage water of the project, after construction	The operation phase needs a regular monitoring programme for canal and drainage water quality with testing for EC, pH, TDS, residues etc.	MIWR
	Downstream effects Sudan and beyond: erosion, lack of water affecting livelihoods.	National policy not to overuse the resource	MIWR
Engineering Impacts	Erosion, deforestation at Dinder weir site; impact on wildlife in DNP.	Careful construction to minimise damage. Replanting.	WIWR and DNP management / FNC
	Erosion, deforestation, disruption of nomad routes along link canal	Careful construction to minimise damage. Replanting	MoA; FNC
	Erosion and deforestation at Rahad weir site.	Careful construction to minimise damage. Replanting	MIWR ; FNC
	Erosion and disruption of farms, nomadic routes along Wad Miskin main canal.	Careful construction to minimise damage. Replanting	MIWR; FNC

Table 8.3: Mitigation Measures (cont)

	Impact	Mitigation Measures	Institutional Bodies Responsible
Soil	Soil erosion by wind or water	Shelter belt (5% from total irrigated area in the project) plantation. Incentive for a farmer to invest in long term soil conservation measures.	Forests National Corporation
	Soil surface disturbed during construction work	Construction traffic should not be allowed to spread over large areas, and trigger unnecessary erosion, if necessary gravel roads should be established for construction traffic.	Contractor responsibility supervised by MIWR
	Continued decline in soil fertility	Adoption of improved soil management techniques and agricultural inputs	Ministry of Agriculture and ARC
Socio-Economic	Loss of traditional grazing and access rights of pastoralists	Maintenance of stock routes and irrigated grazing production areas for nomads	Gadarif State Ministry of Animal and Fish Resources
	Decline of health and public services	Integrated project planning to include provision of adequate health, water, sanitation.	Ministry of Health and other State agencies
	Impact of temporary labour on local economy	Ensure that local existing populations in villages are given and take full opportunity for work	Locality and State education amongst population
Biology and Ecology	Effects on passage of wild animals in the canals	Incorporate structures in the design of the canals that would be provide access for wild animals to the water surface in the canal.	MIWR and Wildlife Administration
	The loss of valuable riverine forest and or fruit trees during construction work, especially where those have stabilizing function for erodible banks.	Compensated by replanting of trees and shrubs after construction phase.	Forests National Corporation ; Ministry of Agriculture
	Increase of malaria in artificially created irrigated project	Prevention and control of transmission through indoor residual spraying and impregnation of bed net.	MIWR and Ministry of Health

Table 8.3: Mitigation Measures (cont)

	Impact	Mitigation Measures	Institutional Bodies Responsible
Biology and Ecology	Aquatic weeds in the irrigation canals. The waters of the Wad Miskin irrigation project as designed should be free of the type of aquatic weeds that affect the Nile system.	IPM, with use of competitive plants to displace the noxious species (biological approach). Regular de weeding activities.	MIWR and Ministry of Agriculture
	Increase in rats, birds and other agricultural pests	Appropriate IPM.	MIWR and Ministry of Agriculture
	Degradation of Forest Reserves	Careful construction to minimise damage. Replanting	MIWR; FNC
Transboundary affects	Use of irrigation water upstream in Ethiopia	Nothing planned at moment but part of old designs	MIWR, NBI, Government liaison

8.2.8 Public Consultation

To make the Wad Meskin Project a success, it will be necessary that all available institutional capacity is utilized in a concerted action, and to help develop the social and economical conditions that will enable the population to seize those opportunities the Project can offer. The initial contacts made to date during the environmental study preparations, include discussions with key stakeholders, as well as interviews held with farmers. These have shown that officials and the people in the project area are largely supportive of the project. A central recommendation is therefore to establish a stakeholder participation and a public information campaign in the project area, once the Tender Design stage has been initiated and the project design is agreed. Although a very useful series of discussions have been made to date with stakeholders these must be regarded as preliminary. There should be a unit responsible for environmental and social issues within the Wad Miskin project management unit, and this unit would be the main mechanism to ensure that the environmental and social safeguarding measures identified in this report, and those further specified during the future tender design phase, and those that may come to light during implementation, will actually be carried out.

During the feasibility study a number of useful discussions have been made with stakeholders by numerous specialists involved in the study. The results of these have been very favourable and the sedentary rainfed farming communities in particular look forward to this project being implemented. The final design though is not yet established and if the project goes to Tender Design then the process of participation and involvement with the stakeholders at all levels will be developed more strongly and positively. A key issue will be to allay any fears amongst the nomadic groups that they will somehow be pushed out of the area.

As we have discussed the traditional rights of the pastoral groups are as strong and worthy as the cereal farming groups, and their contribution to the livestock economy of this part of Sudan must not be allowed to be degraded.

8.2.9 Project Implementation

This section outlines mitigation, monitoring and institutional measure to be taken during further project planning and implementation, in order to ensure that the environmental and social risks identified in the environmental assessment during Feasibility Study are properly addressed, resolved and mitigated in the subsequent project phases as part of an Environmental Management Plan (EMP).

Guidelines for the implementation of an EMP vary from country to country. For many decades in Sudan, as in most developing countries, there was no regulatory framework that laid down the conditions under which development should proceed. Agricultural development for new irrigation schemes, for example on the Roseires Project in the 1960s, used the framework for irrigated land use of the Reclamation Manual of the United States Bureau of Reclamation (USDI, 1953) which laid out the best practices for irrigation planning and development, from the soil conditions through the engineering ones. Later, guidelines were developed by the FAO (FAO, 1976, 1979, 1989) for land resources evaluation of rainfed or irrigation development. These were all based on best practice for an area and encouraged the users to take into account both the bio-physical and social environments. All these had originated in good practices that used to be the norm in development, but had somehow become weakened. Throughout Sudan from the 1960s to the new millennium, development projects that were externally funded used, as a rule, such guidelines, EMPs' in their own way and followed what was and is known as the project cycle. From the early 1980s', due to increasing experience from undisciplined development and project failure, the project planning cycle procedures became more formalised with environmental and social impact assessment guidelines built into development planning, initially by the World Bank and followed soon after by other lending banks and international development agencies including the ADB.

The basic principles of an environmental management plan are numerous. They include that there is an informed decision-making process, and that there is accountability of data and when decisions and the approach is participatory and consultative with public awareness of the development plan. The plan should have considered other alternatives and will aim to mitigate the negative impacts, and enhance the positive ones. At all stages of planning and implementation it will comply with national guidelines and regulatory procedures. The depth of planning that could be reached in this present study for the assessment of environmental and social issues was limited by the time available. It was nevertheless aimed to screen all potentially relevant issues using the ICID method, and the scoping then was able to recommend how to proceed further, and make the assessment as inclusive as possible.

However, due to the given limitations this study does not reach the detailed level of an Environmental Management and Monitoring Plan, which should specify and all necessary measures by type, defined locations, quantities, duration and frequency. For a number of issues, the specification of measures will be possible only during the tender design phase when final areas and affected villages are indicated. For all measures the timing, frequency and duration will have to be specified in an implementation schedule, which must be linked to the overall project implementation schedule. For many important issues, the current recommendations consist of implementing an organizational mechanism that will serve to initiate the more in – depth study and planning of the actual safeguarding activities.

These concerns e.g. a number of more detailed plans for the construction phase, the conducting of which would be the responsibility of the construction contractor, but also important issues in fields such as public health. The first and foremost recommendation in this context would be for the project proponent to implement an Environmental and Social Management Unit, which would specify and approve implementation plans, monitor implementation, identify areas of non-compliance and instruct corrective measures (if necessary in conjunction with local authorities). The implementation and operation of this E & S Management Unit would be the main mechanism to ensure that the environmental and social safeguarding measures identified in this report and to be further specified during the tender design phase and during implementation, would actually be carried out. A central part of the EMP is monitoring of the project so that predicted and actual impacts can be compared. On the Wad Miskin project the key monitoring issues will be made during both construction and implementation. They are recommended to address the following as essential components: monitoring any changes in water quality, changes in soil fertility, status of aquatic ecosystems and biodiversity, changes in water related health issues, impacts on pastoralist routes, changes to traditional livelihoods, demographic trends, changes to crop production and markets.

All these have to be judged in relation to a baseline established before the project starts. As such the first task of the EMP, in the run up to the start of construction, and probably best initiated at the start of the Tender Design stage, will be to:

- Provide an update to the local population and other stakeholders in the area of the final project plan - what impacts it might have and what mitigations are necessary. It will be essential to enlist their support in these issues. This will be made by the ESMU staff in cooperation with staff from other agencies in Hawata or Gadarif. Limitations of the exiting agencies, for livestock for example, are given Annex 6, and it will be necessary to provide some from of budgetary upgrade to these agencies first so their participation in the project will be useful.

- Bring up to date any and all existing environmental, agricultural cropping and livestock, forestry, and social datasets, from sources in Hawata, the locality town. If none then such data collection must be initiated by special surveys, such as fro fisheries and aquatic ecosystems. It will be very advantageous to establish a full automatic climate station in Hawata, ideally at the same location where rainfall used to be collected but is no more.

- Initiate regular testing of waters in the principal sources (the Hawata – Wad el ‘Ageili sources are already tested on a regular basis at the Hawata compound). The Ministry of Irrigation (Hawata station) would be responsible for this. Any shortfall in equipment and staff capability will be identified during the initial stage of Tender Design. A budget for this section will be required. The testing could be made at the Hawata water supply compound or elsewhere.

- Ensure that hydrologic flows in the Rahad and Dinder are measured at all times in the flood season ;

- Make a detailed examination of the influence of the connection between the Rahad and Dinder rivers by the Khor Al Atshan channel link. The Ministry of Irrigation (Hawata station) would be responsible for this, as noted above.

8.2.10 Discussion on ‘without the project’ Impact

Economic analysis for a project traditionally looks at the ‘without project’ or ‘no project’ scenario where conditions in the project area are assessed assuming, as in this case, no irrigation development will take place. This sections looks at what would be the likely impacts to occur in the Wad Miskin area if an irrigation supply was not taken from the Rahad (and conceivably the Dinder).

To gauge the likely trends that would take place in the rural economy without irrigation it is necessary to have a baseline on which to measure subsequent change.

In the Wad Miskin area, both for the proposed irrigation area, the structures on the Rahad and Dinder, and canals there is considerable information from the soils, agriculture, livestock, land-tenure and socio-economic studies made for the Feasibility Study. These baseline data have been obtained in the project area during 2008-2009.

The rural economy of the wad Miskin area is one dominated by rainfed agriculture for cereals, mainly sorghum. There are some fruit trees – mangos principally - along the Rahad. These are fed by groundwater and supplemented with irrigation from pools during the dry season. These areas, though, lie outside the proposed irrigation area. Similarly, and on the edge of the proposed irrigation area, there are flooded old river channel depressions (*maya)* that have fishing possibilities that can be sustained throughout the year.

Within the proposed irrigation belt the lands are under a system of long rotation for cereal cropping with certain parts always under bushland. This rainfed belt extends far to the east of the project boundary but within ten kilometres there are numerous villages and hafir. In the cropping year 2009-2010 there was almost complete crop failure in the proposed irrigation area due to a number of reasons. This was a complete disaster for farmers and many are said to selling livestock to make ends meet. It appears that farmers were encouraged to plant widely this past year as 2009 was going to be an exceptional year for rainfall and bumper harvest. This was unfortunate if true, as nobody can forecast the rainfall pattern. As it happened, the rain started early and with some intensity that gave farmers great hope, so most planted: the rains then stopped over a huge area between Singa and Gedaref, and did not return. The result was that crops used up the soil moisture that was accumulated form this first rainfall phase and then withered.

This is the pattern of rainfed cropping in the area, which would be the 'without project' situation in several years in a decade perhaps: an analysis of rainfall and crop harvests could provide a better indication of the risk a farmer faces.

An alternative tactic in this area would be to make more use of the *teras* system of water harvesting capturing runoff into field and then passing it onto the next field down slope. There is at present little field evidence that this method, common in other parts of the Butana, is adopted. In any case the land is quite flat and the scope for *teras* improvement here is low, as it depends often on runoff water moving from a moderate to long distance upslope.

Whilst the *teras* system could alleviate water shortage in small areas, it cannot flood the entire area. Based on the 2009-2010 experience the 'without project' situation is clearly outshone by the proposed project that would, using a small portion of the Rahad flood, have the potential to provide food security in this region. Thus, the impact of the 'no project' situation would mean that farming would continue to be a very risky business. As it exists now, farmers are reluctant to put more inputs into the soil and adopt better varieties, and improved land husbandry and management, as they stand to lose all their investment if there is low rainfall and crop failure. The irrigation project, by contrast, appears to offer, at least for this small area, a chance for better food security.

8.2.11 Conclusions

The mitigation measures (Table 8.2) that are recommended to be taken further during detailed project planning, and then in implementation, are made in order to ensure that the environmental and social risks identified in the environmental impact assessment are properly addressed. If they are not then the project will fail in its duty to protect and sustain the environment.

Because the project is command area is in a fixed area the location of weir sites on the Rahad is also determined by this. There are thus no alternatives that can be offered to the area. The without or no project situation would mean that the area remains under rainfed agriculture with its persistent risk of reduced rainfall and crop failure.

This section outlines mitigation, monitoring and institutional measure to be taken during further project planning and implementation, in order to ensure that the environmental and social risks identified in the environmental assessment during Feasibility Study are properly addressed, resolved and mitigated in the subsequent project phases as part of an Environmental Management Plan (EMP).

Guidelines for the implementation of an EMP vary from country to country. For many decades in Sudan, as in most developing countries, there was no regulatory framework that laid down the conditions under which development should proceed. Agricultural development for new irrigation schemes, for example on the Roseires Project in the 1960s, used the framework for irrigated land use of the Reclamation Manual of the United States Bureau of Reclamation (USDI, 1953) which laid out the best practices for irrigation planning and development, from the soil conditions through the engineering ones.

Later, guidelines were developed by the FAO for land resources evaluation of rainfed or irrigation development. These were all based on best practice for an area and encouraged the users to take into account both the bio-physical and social environments. All these had originated in good practices that used to be the norm in development, but had somehow become weakened. Throughout Sudan from the 1960s to the new millennium, development projects that were externally funded used, as a rule, such guidelines, EMPs' in their own way and followed what was and is known as the project cycle. From the early 1980s', due to increasing experience from undisciplined development and project failure, the project planning cycle procedures became more formalised with environmental and social impact assessment guidelines built into development planning, initially by the World Bank and followed soon after by other lending banks and international development agencies including the ADB.

The basic principles of an environmental management plan are numerous They include that there is an informed decision-making process, and that there is accountability of data and when decisions and the approach is participatory and consultative with public awareness of the development plan. The plan should have considered other alternatives and will aim to mitigate the negative impacts, and enhance the positive ones. At all stages of planning and implementation it will comply with national guidelines and regulatory procedures.

8.2.12 Proposals for Wad Miskin

The depth of planning that could be reached in this present study for the assessment of environmental and social issues was limited by the time available. It was nevertheless aimed to screen all potentially relevant issues using the ICID method, and the scoping then was able to recommend how to proceed further, and make the assessment as inclusive as possible.

However, due to the given limitations this study does not reach the detailed level of an Environmental Management and Monitoring Plan, which should specify and all necessary measures by type, defined locations, quantities, duration and frequency. For a number of issues, the specification of measures will be possible only during the tender design phase when final areas and affected villages are indicated. For all measures the timing, frequency and duration will have to be specified in an implementation schedule, which must be linked to the overall project implementation schedule. For many important issues, the current recommendations consist of implementing an organizational mechanism that will serve to initiate the more in – depth study and planning of the actual safeguarding activities.

These concerns e.g. a number of more detailed plans for the construction phase, the conducting of which would be the responsibility of the construction contractor, but also important issues in fields such as public health.

The first and foremost recommendation in this context would be for the project proponent to implement an Environmental and Social Management Unit, which would specify and approve implementation plans, monitor implementation, identify areas of non-compliance and instruct corrective measures (if necessary in conjunction with local authorities). The implementation and operation of this E & S Management Unit would be the main mechanism to ensure that the environmental and social safeguarding measures identified in this report and to be further specified during the tender design phase and during implementation, would actually be carried out.

8.2.13 Monitoring

A central part of the EMP is monitoring of the project so that predicted and actual impacts can be compared. On the Wad Miskin project the key monitoring issues will be made during both construction and implementation. They are recommended to address the following as essential components: monitoring any changes in water quality, changes in soil fertility, status of aquatic ecosystems and biodiversity, changes in water related health issues, impacts on pastoralist routes, changes to traditional livelihoods, demographic trends, changes to crop production and markets.

The African Development Bank (AfDB, 2003) provided a detailed list of monitoring indicators on irrigation projects, under the general headings of poverty, environment, population, health outcomes, gender and participation.

The management of future Wad Miskin project would follow these guidelines on a regular basis. Technical and non-technical issues would be the responsibility of the relevant department of the project (administration, engineering, water supply, health and safety, agriculture ; transport; settlements etc). Other data is already collected in the area by the Locality departments in Hawata and the projects would need to come to data-sharing agreements with these organisations.

We have added suggested estimates of the frequency of monitoring activities within each section, as follows:

Poverty Indicators - Economy

- Number of jobs created (directly and indirectly) and occupied by men and women; *Frequency:monthly.*
- Level of satisfaction of adversely affected men and women toward compensations and offered alternatives (survey). *Frequency: annual*

Information, Education and Communication

- Acquired irrigation systems management skills by trained men & women. *Frequency: annual*

Access to Infrastructures and services

- volume of sedimentation in irrigation canals to evaluate soil degradation; *Frequency: monthly*
- maintenance expenses on irrigation canals; *Frequency: monthly*
- number of breakdowns of the irrigation systems; *Frequency: daily in the flood season*
- number of water points as a function of the population; *Frequency: monthly*
- number of domestic water supply breakdowns. *Frequency: daily reporting*

Environment – Water

- Groundwater static level and refilling capacity. *Frequency: weekly at key sites*

- Parameters of *WHO Guidelines for Drinking-water Quality* for evaluating the physico-chemical characteristics of underground and surface water quality (upstream, on the site and downstream). *Frequency: weekly to monthly (liaise with Wad Ageili company).*
- Coliforms and viable intestinal nematode eggs per litre for evaluating wastewater quality for irrigation purposes (*WHO Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture*). *Frequency: weekly to monthly (liaise with Wad Ageili company).*
- Quantity of water used compared to initial estimates. *Frequency: weekly.*

Environment – Soils

- Volume of sedimentation downstream of irrigated area. *Frequency: weekly in flood season*
- Changes in soil physical and chemical parameters (e.g.: pH, salinity, water retention, etc.). *Frequency: weekly to monthly, with annual checks at bench mark sites*

Environment –Ecosystems

- Surface of sensitive areas affected by the irrigation project. *Frequency: monthly.*

Environment – Flora:

- Area covered by aquatic plants in canals. *Frequency: monthly.*
- Biomass per inhabitant nearby the project area. *Frequency: annual.*

Environment -Natural and cultural heritage:

- Natural and cultural sites affected by the project. *Frequency: daily checks during construction.*

Population - Demographic trends

- Population growth and ethnic composition. *Frequency: annual*

Population - Migration and Resettlement

- Type of house and accessible services to displaced men and women before and after project implementation. *Frequency: monthly.*
- Integration level of migrants in host communities (survey). *Frequency: monthly consultations to annual.*
- Number of informal settlements built by migrants. *Frequency: monthly.*

Natural Resources and Land Management

- Subsistence production in calories per inhabitant. *Frequency: annual.*
- Presence of a water user organisation, including men and women. *Frequency: monthly checks on status, higher in flood season.*
- Revenues from irrigation water fee collection and allocation. *Frequency: monthly.*

Quality of life

- Level of satisfaction of displaced men and women (survey). *Frequency: annual.*

Health Outcomes - Communicable Diseases

- Prevalence rates of diseases such as malaria, schistosomiasis, diarrhoea and HIV. *Frequency: monthly liaison with health centres.*
- Number of vector breeding sites and vector density. *Frequency: annual surveys.*
- Availability of condoms, impregnated bed nets, mosquito repellents. *Frequency: weekly status.*
- Outpatient attendance records. *Frequency: monthly.*
- Quantities of drug supplied/used from health services & local shops. *Frequency: monthly*

Health Outcomes - Non-Communicable Diseases

- Inventory of exposure sites including wastewater drainage. *Frequency: monthly.*
- Water quality analysis results. *Frequency: monthly to bi-weekly.*

Health Outcomes - Malnutrition

- Number of people affected by seasonal hunger (evolution over time). *Frequency: annual.*
- Height/weight monitoring of children. *Frequency: annual.*

Health Outcomes - Injuries

- Number of violent events reported by the police & social services. *Frequency: annual.*
- Construction site occupational health and safety records. *Frequency: daily checks.*

Gender - Division of labour

- Time allocation of women before and after the irrigation project. *Frequency: annual*
- School attendance of girls / boys before & after the irrigation project. *Frequency: monthly.*
- Number of children working on a regular basis in irrigated schemes. *Frequency: monthly.*

Gender - Income-Generating Activities

- Proportion of family income received and managed by men and women before and after the project. *Frequency: monthly.*

Gender - Access to and Control over Productive Factors

- Proportion of men and women being owners or tenants of irrigated schemes. *Frequency: annual.*
- Level of satisfaction of women toward project investment decisions & management methods (survey). *Frequency: annual.*

Gender - Involvement in Societal Organisations

- Number of women and men involved in user organisations. *Frequency: annual.*

Participation - Civil Society Strengthening

- Level of participation of user organisations in the water management decision-making processes. *Frequency: monthly.*

- All these have to be judged in relation to a baseline established before the project starts. It is known there are gaps in the baseline data and the sections below suggest how these might be filled. As such the first task of the EMP, in the run up to the start of construction, and probably best initiated at the start of the Tender Design stage, will be to:

- Provide an update to the local population and other stakeholders in the area of the final project plan- what impacts it might have that effect their environments and their livelihoods, and what mitigations are necessary if these are negative. The positive aspects too will be discussed and the economic advantages as such outlined. It will be essential to enlist their support in all these issues. This will be made by the ESMU and MIWR project staff in cooperation with staff from other agencies in Hawata or Gedaref.

- Limitations of the exiting agencies, for example for livestock management given Annex 6 will require serious decisions to ensure that they modernise and improve. It will be necessary to provide some form of budgetary upgrade to these agencies first, so their participation in the project and to others will be useful.

- Bring up to date any and all existing environmental, agricultural cropping and livestock, forestry, and social datasets, from sources in Hawata, the locality town. If none then such data collection must be initiated by special surveys, such as for fisheries and aquatic ecosystems.

- It will be very advantageous to establish a full automatic climate station in Hawata, ideally at the same location where rainfall used to be collected. This should be achieved at an early stage, preferably during the detailed design stage, and will involve establishing modern climate station at site of old defunct station. This will take digital data readings every hour of a wide range of parameters including: rainfall, rainfall intensity, maximum and minimum temperatures, dry and wet bulb temperatures, soil temperatures, wind speed and direction, sunshine hours, solar radiation, evaporation, soil moisture.

- Initiate regular testing of waters in the principal sources (the Hawata – Wad el 'Ageili sources are already tested on a regular basis at the Hawata compound). The Ministry of Irrigation (Hawata station) will be responsible for this. Any shortfall in equipment and staff capability will be identified during the initial stage of Tender Design. A budget for this section will be required. The testing could be made at the Hawata water supply compound or elsewhere.

- Ensure that hydrologic flows in the Rahad and Dinder are measured at all times in the flood season; and make a detailed examination of the influence of the connection between these rivers by the Khor el 'Atshan channel link. The Ministry of Irrigation (Hawata station) will be responsible for this, as noted above.

- Make a series of sediment measurements in the Rahad and Dinder Rivers during the floods and at low water flows.

- Make a survey of fish in the Dinder and Rahad and mayas, and examine the role of fish migrating up these rivers into the catchments during the floods.

- Gaseous emissions from livestock. The review of the draft report mentioned this as a possible impact in the area, presumably, though not stated, from increased methane production. The project does not see a substantial increase in livestock in the area and this is not seen as serious negative possibility. Some air quality monitoring should be included, but there is no baseline on this.

- Soil Fertility. The steady decline in yields is seen due to a loss of fertility in the soils by many. But it is a complicated issue and a key element is livestock manure. Livestock manure has an important role in the rural economy as components of brick making, as fuel for domestic fires, and as fertilizer incorporated into the soil, though not usually deliberately. In fact, animal manure and crop residues are the only inputs into the soil, usually by falling down cracks of the Vertisols where the recycling of nutrients is a key and generally completely unheralded part of the long term fallow cycle in the rainland soils, whereby soils recover some level of fertility. Because the additions fall down to 1m or so in the soil they are utilised by arboreal vegetation rather than shallow rooting cereals. Thus the tree vegetation recovers but not the topsoil. Studies in the past on the rain lands by the Soil Survey Administration concluded that under continuous monoculture of sorghum (even on the areas scheduled for rotation) and with shallow ploughing some form of poorly structured and compacted layer had formed. This was not a hard pan as believed by some. This could be broken by deep ploughing but this advice was not generally followed.

- In the proposed irrigation area of Wad Miskin soils will be wetted more than under rainfed conditions and this phenomenon should not occur. But, the whole issue demands a monitoring programme to assess changes and progress.

- Project machinery could be hired out to deep rip rainfed soils in other areas during the dry season.

- The project could and should play a very useful role here with routine monitoring of bench mark soils, where there is now up-to-date analysis including trace elements from several soil profiles whose location is known exactly (unlike older datasets). Re-sampling should be made every few years. At the same time sites should be sampled for soil moisture measurements at depth down profiles throughout the year. Associated monitoring would include climate, farming practices and agricultural inputs.

- Pests. Traditionally, and we support this, the local (State) offices of Ministry of Agriculture, in Hawata for Wad Miskin area (Gedaref State) and in Quweisi (Dinder for Sennar State) for the Dinder river areas, are supposed to provide, in coordination with the Federal Ministry of Agriculture and Forests, Plant Protection services, regarding pan territorial pests such as rats, locusts and *quelea*, to farmers. Their capacity to do this is weak, and according to the recent World Bank funded semi-mechanized rain-fed farming study (Newtech-HTSPE, 2009) any services that are applied are too late and are of inadequate coverage. Technical innovations that should come from the Agricultural Research Corporation (ARC) are hampered by the fact that the ARC is no longer part of the Ministry of Agriculture but lies now within the Ministry of Science and Technology, and there are no formal links between the ARC and the State Ministries of Agriculture (Newtech-HTSPE, 2009). Currently, according to Newtech-HTSPE (2009), the State Governments are now responsible for Extension Services, but lack the capacity to do so. As this seems to be because of lack of funds, then the project could help to strengthen their ability to do this. These organizations must be improved and links to research forged.

To summarise on the key issues where monitoring needs to be started soon, and this should in reality be not just for the proposed project but for the region as a whole. In any case the key issue will incorporate some of the proposal above and make provisions for, and commence funding of, programmes to fill the gaps in the baseline data situation. We have identified that information is needed on: *maya* ecology, fishing, fauna and flora, climate data, decline in soil fertility, hydrologic flows on rivers, sediment loads on the rivers, and water quality testing. Some of these are made at Hawata but need upgrading.

8.2.14 Environmental and Social Management Unit (ESMU) Costs

An Environmental and Social Management Unit (ESMU) would be established as part of the project's construction supervision office / Project Management Unit. It is recommended that there should be three staff: one land and vegetation specialist; one aquatic biologist; and one social environmentalist professional working in this unit, with individual staff cost of SDG 15,000 /month. Additional specialists might have to be called in, for example, pesticide management, range management and livestock husbandry: these should be available in line agencies in Gedaref State. The permanent staff should be recent graduates, but with MSc in these fields, and good experienced in environmental impact assessment and mitigation. They should be willing to devote several years to this project. The ADB could provide additional advanced specialised training and / or short courses in Sudan or overseas, for the selected staff.

Staff could use the same office locality as the project implementation supervision staff, but must be seen also to be independent and supporting the overall aims of the project to assist the local peoples.

They will though have direct link to the resident engineer and will be key participants in all decisions on the construction where mitigation is involved.

Realistic costs estimates for the identified mitigation measures are difficult to give at the current stage of planning. This is due to a limited degree of overall project planning, at which the detailed scopes and quantities for mitigation measures have not been identified yet. For these issues, we recommend that the cost estimates can be updated on a more profound basis during the detailed/tender design phase.

Recurrent costs/environmental monitoring during construction and first five years of implementation:

- 40,000 SDG / year for bio-physical (soil, vegetation ecosystem) environmental monitoring at weir sites, along the canals and in *maya* wetlands. In addition we would cost for a set of monitoring meters (1: Electrical Conductivity + pH + TDS) for setting up in a small laboratory equipped with bench. Ideally samples are collected in the field and brought to the laboratory. Cost allow €1000 for robust instrument and associated glassware equipment; (2: A 50m dipmeter for measuring water table depth is useful. Cost €300 euro; (3. Furniture and start up consumables for the laboratory. Cost €1000 euro; (4. Annual consumable costs of €500, including purchase of distilled water from LWRC laboratory in Wad Medani, buffers and replacement glassware etc.

- 40,000 SDG / year (settlements, health, water) year for monitoring of social issues. These includes transport into the site, laboratory testing for water related diseases in the Rahad, *maya* and hand pumps. No analysis of water for biological test would be made on site, but arrangements to take these to reputable laboratory in Sennar or Gedaref within normal time-frame allowed between sampling and analysis, needs to resolved during detailed design. Use of testing facilities at Hawata / Wad Ageili water company might be possible. Allow a further €2000 / year for this. Water quality testing once a month from about 5 selected locations

- 20,000 SDG / year for public information and meetings in Hawata and villages. A permanent display should be set up in Hawata to advertise the progress of the project. This would cover costs of printing and distribution.

- Annual auditing of the ESMU and its output will be essential to demonstrate that the EMP is proceeding as desired. This audit should be made by an independent body selected by the HCENR. In turn the ESMU will report regularly to the MIWR and HCENR on progress in its work so that any shortcomings in the design and problems with stakeholders can be identified at an early stage and attempts made to resolve issues.

8.2.15 Conclusions

As has been emphasized throughout all Feasibility Study reports and annexes of the Wad Miskin Agricultural Development Project (WADP), this development of the project would be a major undertaking in the region, which cannot be limited to constructing the irrigation infrastructure, without also considering the necessary social, economical, institutional and policy framework. In any irrigation development project the technical and social planning are both important (ICID & WB, 1998).

By paying close attention to the social and environmental conditions alongside the technical engineering can not only greatly enhance the benefits of the project for the population, but is actually crucial for its success.

The initial contacts made to some important stakeholders during the environmental study preparations, as well as interviews held with farmers, have shown that officials and the people in the project area are largely supportive of the project. The failure of the rains in the Hawata area in 2009 with widespread crop failure, and the apparent record low flow record of the Rahad River, have alerted all to the fragility of their livelihoods. The advantages of a scheme that would take a small proportion of the Rahad flood flow and transform it is hoped a predominantly subsistence rainfed area into a more stable one will be welcomed in the area.

To make the Wad Miskin project a success, it will be necessary that all available institutional capacity is utilized in a concerted action, and to help develop the social and economical conditions that will enable the population to seize those opportunities that the project can offer. A central recommendation is therefore to establish a stakeholder participation, and a public information campaign in the project area. This would be coordinated by an environmental and social assessment unit established within the project management unit. This unit would be the main mechanism to ensure that the environmental and social safeguarding measures identified in this report, and those further specified during the future tender design phase, and also of course during implementation, will actually be carried out.

Monitoring of possible impacts is essential, as there are substantial risks to land, water and vegetation if extreme care is not taken during constriction and implementation. Some key monitoring issues will include:

- To avoid negative impacts of polluted drainage water on natural water bodies or on water uses for domestic purposes, canal and drainage water by regular assessment of water quality.

- To avoid any groundwater pollution of the 'Atshan aquifer, from intrusion of agrochemicals into the shallow groundwater aquifers. These are used for drinking water supply in many locations. It is necessary to monitor regularly the groundwater quality in order to detect any such impacts. Parameter should include pH, TDS, Nitrate, P04, BoD, coliform bacteria, and pesticide residues. The testing at Hawata by the water corporation should be stepped up and the ADB could help finance this upgrading so that it becomes part of the project monitoring and testing capability

Based on the final design, further areas where protection or compensation measures are to be established have to be specified. This will include:-

- Areas disturbed during construction that need to be re-planted with trees and shrubs to protect river bank from erosion. Safety provision at canal crossings at places where canals are used for domestic and wildlife purposes, and in regular intervals along the canals. Safe design for structures and equipment for storage and handling of water-endangering and hazardous substance (e.g. fuel storage, fertilizer and pesticide storages). Wastewater from all construction sites shall not be allowed to be discharged uncontrolled over land on into surface water drains or rivers. To control aquatic weeds in the irrigation canals biological control (IPM) is recommended.

Chapter 8 references

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9. FINANCIAL AND ECONOMIC ANALYSIS

9.1 MAIN ASSUMPTIONS, PARAMETERS AND METHODOLOGY

The aim of the financial and economic analysis is to assess whether or not the project is financially and economically viable. The usual process includes three levels of analysis:

- Assess the return on investments, at short and medium term, on the basis of financial analysis, with components as debt service and cash flow status. For doing so, the available financial data have to be reviewed for carrying out analysis at the farm level and for identifying shadow prices.
- Make a "with the project" estimate of the costs and benefits at farm level based on the household food needs and monetary income, and check whether or not farmers will have the capacity to pay for the irrigation water fee.
- Quantify the benefits of the project for the national economy through the economical analysis

For the proposed irrigation project, the financial and economic analysis are built on Cost-Benefits Analysis and the return on investment. A specific attention is given to the estimates of all costs and prices. In both analyses, the actualization technique is used for the cost and benefits occurring in the course of the project. A discounting rate of 12% is currently used in Sudan (MoIWR). The financial analysis tells whether or not the project is feasible from an investor's perspective, the financial return on investment being the main criterion. The economic analysis determines the added value of the project for the national economy (contribution to GDP growth). Therefore, the financial analysis uses market prices while the economic uses shadow prices. Shadow prices are meant to actually reflect the opportunity costs of foregone resources to ensure that the project impact on national welfare is well accounted for. Since information on market prices is usually more readily available than data on shadow prices, market prices are generally used as a basis for estimating shadow prices. The analysis at household (or farm) level is done for one model farm using market prices (financial analysis) to estimate the cost, benefits, farmers' income and food self-sufficiency status. In addition, the analysis takes in due account the financial contribution of farmers to the management, operation and maintenance costs of the proposed irrigation project.

9.1.1 Components of Cost-Benefit analyses

In projects financial & economic studies, results usually depend on the baseline data used and the level of precision in the description of project features. Before running a cost-benefit model, extensive work is required to prepare accurate data, i.e. identifying the amount of investments and the production costs and benefits of the farming system. Details on data are presented in Annex 12. In the present case, one particularly important and essential task was to estimate the amount of investments and to describe the "with the project" agricultural production systems.The amount of investments is the starting point in the Cost-Benefit analysis (CBA) of any project. The investments of a project must be considered in their spatial (area), economic (utilisation of rare resources such as soil and water) and social (number of beneficiaries) dimensions. For the CBA analyses a lot of data has been collected to describe:

- All categories of investments: Investment components should be detailed (civil works, equipments, on farm irrigation systems, management, technical assistance, agriculture extension service and so on) and the impact of each investment component should be assessed, e.g. increase in production, yields evolution regarding climate changes, and other factors that can influence the financial performance.

- The recurrent costs linked to the operation and maintenance of the main infrastructures (conveyance channel, pumping stations) and equipments (hydrants, farm irrigation systems).

- The general and economic assumptions on price indexes, local inflation and exchange rate of the Sudanese Pound with US$ to properly forecast various cost components. This also includes assumptions on costs, whether these are based on local or international cost and indexing factors.

The description of the "with the project" agricultural production systems is the basis for assessing whether or not the project will meet the objectives of food security and increased farmers' income. The analyse focuses on the following items.

- The situation before the project: limited cropped areas in the vicinity of the two main cities Hawatta and Bazoura, used to grow food crops mainly meant for home consumption and breeding of approx 3,400 heads of cattle: sheep, goats and camels.

- The situation with the project: command area of the irrigation scheme, amount of available water for irrigation, cropping patterns and crop production systems and number of beneficiaries.

- The technical assumptions for the proposed cropping patterns on production and yields, labour requirements and costs, agricultural inputs use, energy and O&M costs. This makes possible assessing the development of each item in the course of the project.

- The detailed assumptions on incomes based on yields and production, marketed production and home consumption.

- The detailed assumptions on irrigation water requirements.

- The market data: In the general context of the project, it was considered that targeting the local market is the best option at least for the short and mediums terms.

- The use of farm-gate prices for estimating the sales amount of agricultural production. For this irrigation project, average annual market prices were considered as the most reliable data. Estimates of farm gate prices are based on first hand information provided by farmers in the area project.

All the above points of can be addressed when conducting a Cost-Benefit analysis. Over a given period of time, a cost-benefit analysis takes into consideration:

- The various investment phases,

- Various rates of production growth so that land and water availability can be taken into account as well as the change in the technology used by the farmers and climate related risks.

9.1.2 Developing of the model

In a CBA a project consists in a series of costs and benefits occurring over a number of years. The figures materialise in a positive or negative cash flow balance throughout the project. The number of years considered for the proposed project is 50 years for determining the financial and economic IRR, and 20 years for the detailed cash flow status.

A discount rate is applied to enable comparison over the years. Here a 12% rate is used in line with the recommendations from MoIWR. It is important reminding that this actualization method is totally independent from inflation or monetary erosion. The main expected results will be the F-IRR, E-IRR, NPV, and B/C analysis. All these indicators will be produced by financial and economic models, and completed by the sensitivity analysis. Market and shadow prices are in constant Sudanese pounds (SDG) at the date of November 2009. Further details are presented in Annex 12.

9.2 FINANCIAL ANALYSIS OF FULL DEVELOPMENT OF 107,500 HA IN WAD MESKIN AND RAHAD 2

9.2.1 Investments and renewal expenses

Total investment costs amount to 1,434 millions SDG. This amount is distributed over 3 main investment phases over 20 years. The investments costs are estimated at market prices in November 2009. The total amount includes the project study and design costs.

Table 9.1: Implementation program

WAD MESKEEN IRRIGATION PROJECT							
Implementation program		Financial values					
	Phase1 Wad Meskeen 7 500 ha supplementary irrigation	Phase 2: Rahad 2 supplementary irrigation	Phase 3: Wad Meskeen & Rahad 2 dry season irrigation	Area with equipement ha	Area in operation Rainfed +irrig. ha	Area in operation Double cropping ha	Investments M° SDG
years							
1	Barrage Wad Meskeen & Main canal			0	0		3.77
2	Barrage Wad Meskeen & Main canal + irrigation system			2 500	0		30.49
3	Irrigation system & On-farm development			2 500	2 500		26.71
4	On-farm development & supporting investments			2 500	5 000		26.71
5					7 500		
6					7 500		
7					7 500		
8					7 500		
9					7 500		
10		Barrage on Dinder river + Link canal & associated structures			7 500		38.70
11		Barrage + Link canal & associated structures + Irrigation system +on-farm equipment		10 000	7 500		205.41
12		Extension main canal + Irrigation system & On-farm development		10 000	17 500		121.73
13		Irrigation system & On-farm development		10 000	27 500		100.58
14		Irrigation system & On-farm development		10 000	37 500		100.58
15		Irrigation system & On-farm development + supporting investments		10 000	47 500		133.33
16		Irrigation system & On-farm development		10 000	57 500		100.58
17		Irrigation system & On-farm development		10 000	67 500		121.73
18		Irrigation system & On-farm development + supporting investments		10 000	77 500		116.25
19		Irrigation system & On-farm development	Roseires link to Dinder barrage + Development for double cropping	10 000	87 500		150.11
20		Irrigation system & On-farm development	Roseires link to Dinder barrage + Development for double cropping	10 000	97 500		144.23
21			Development for double cropping + supporting investment		86 000	21 500	8.40
22			Development for double cropping		64 500	43 000	2.53
23			Development for double cropping		43 000	64 500	2.53
24						107 500	
Total				107 500			1 434.36

These figures include a 15% contingencies rate for all costs. The investments are mainly civil works with a service life of 50 years. Therefore renewal costs are not included in the present analysis.

9.2.2 Recurrent costs

The recurrent costs are operation, maintenance and management costs:

- Operation and maintenance costs are usually assessed as a percentage of the equipment and infrastructures; the percentage is 1% for operation and 1% for maintenance.
- The management costs relate to the supervising authority activities including salaries and contingencies costs and to the IWUA organization, including water management in the field. This cost is included in operation costs.

The absence of pumping system in the project explains a weak energy charge only taking account management infrastructures and security needs; they are gathered with all operating expenses.

9.2.3 Project benefits

The only source of benefit for the project is the profit resulting of agricultural production. It is the difference between the gross value of the agricultural production and agricultural production costs. To calculate the benefits, the following items must be considered:

- **The yield of each crop.** They increase during the first years of the project as a result of adoption of improved technology packages by farmers. They stabilized from the 4th year onward for cereals, oil seeds and vegetables. Harvest and post harvest losses are estimated at 10% of agronomic yields.

- **The farm gate prices.** They were considered as constant all along the number of years considered for analysis. It is well known that market prices fluctuations happen all the time, therefore it is best using the annual average price for a long term analysis. Only 90% of the market prices were used to take into account transaction and marketing costs. This percentage drops down to 80% for export products (Okra and Melon).

- **The commercial income.** In a financial analysis, only the income from marketed commodities has to be considered as a benefit. The agricultural production kept for home consumption has no financial value. Therefore, to assess the part of the production sold on the market, a specific ratio (Production sold/total production) is applied to each crop reflecting its importance in the daily diet of farming households.

- **The production costs.** They increase with irrigation development (more labour), and also with the yields (more inputs, and more handling and packaging equipments).

Table 9.2 shows the **profit per ha** of the various crops in the project cruising years (year 7 and onward). It is no surprise that cash crops, namely purslane, sweet potatoes, and products for export market, provide the highest profit. High market demand explains their high profit.The cash crops (vegetables) are essential to farmers' income as they sell around the year but also for improving the diet of farming households. The same enlightens the weight of farm gate prices in profit building. The export prices are undoubtedly more attractive but dependant on market organisation and capacity to reach the international demand. The volumes devoted to export market were kept low to ensure a good price and to avoid excessive marketing costs. The cropping pattern favours the cereals to insure food security and improve Sudan's export/import balance of payments. The two advantages of cereals are their good financial response and their high storage ability. Cereals are the first secure productions of the cropping pattern. Amongst traditional crops, sesame generates a good profit resulting from high yields compared to the average ones in Sudan. Good soils and an adequate irrigation management would allow confirming the general increase of productivity kept in the model. Sorghum is not ranking well in spite of good yields because market prices of sorghum are relatively low. Table 9.3 shows the gross profit for the whole command area (7,500 ha).

Table 9.2: Agricultural gross profit per ha, in full regime situation

WAD MESKEEN IRRIGATION PROJECT		FINANCIAL VALUES				
Resuls for 1 ha		YIELDS tradable	Farm gate price	Gross value of agricultural production	Production costs	Gross profit
		qt/ha	SDG/qt	SDG/ha	SDG/ha	SDG/ha
	Sorghum	27.7	62.5	1 734.0	838.0	896.0
	Groundnuts	30.3	137.5	4 171.3	723.0	3 448.3
	Sesame	16.8	237.5	3 981.6	722.0	3 259.6
	Sunflower	15.3	100.0	1 534.5	843.0	691.5
	Okra	124.4	100.0	12 437.0	1 099.0	11 338.0
	Okra export	126.0	200.0	25 200.0	1 099.0	24 101.0
	Melon	170.0	78.0	13 260.4	1 099.0	12 161.4
	Melon export	172.8	130.0	22 464.0	1 099.0	21 365.0
	Cucumber	358.3	32.5	11 645.5	1 099.0	10 546.5
	Sweet potato	340.9	70.0	23 861.8	1 099.0	22 762.8
	Water melon	259.3	17.9	4 641.9	1 099.0	3 542.9
	Rocket	150.3	80.0	12 021.5	1 099.0	10 922.5
	Jewsmallow	171.4	25.0	4 285.1	1 099.0	3 186.1
	Purslane	214.3	364.5	78 120.8	1 099.0	77 021.8
	Total					

The profit is the value of agricultural production minus the production costs. In the case of double cropping, the same cropping pattern can be adopted for the winter crops after completion of the link channel to the Roseires barrage. During winter (= dry season), it would not possible to obtain the same yields and the cropping intensity could be affected by climate change. In some cases, it is not possible to plant winter crops immediately following sorghum. In such cases a portion of the farms area would be left fallow after harvesting sorghum. Therefore the average yields of winter crops have been estimated at only 40% of those of summer crops. However, to take into consideration the agronomic constraints and to avoid soil fertility impoverishment, the production costs of winter crops are equal to those of the summer crops. At the same time, double cropping implies increased labour requirements and more wages to distribute.

For the proposed cropping pattern, the overall benefit of the project depends upon the respect of the implementation program and yields increases during the first four years of operation. For the first phase of implementation, the full regime of the project is reached only in the 7th year of operation when the irrigation management performance has reached a satisfactory level. After implementation of the third phase, the full regime will be reached not sooner than the 25th year. All results are given in Appendix 12-7.

The figures in Table 9.2 indicate there is no significant growth of the profit. This due to the area developed, less than 10% of the 107,500 ha total area. From the 12th year onward, the project enters a phase with a fast profit increase and a much slower increase of production costs. The reasons why are increased inputs supply and adoption of improved technology packages by farmers. The benefits generated by livestock production would increase significantly with the projects resulting of more productive grazing areas and a higher number of drinking facilities for livestock. Therefore to compare the situation "with" and "without" the project, a realistic increase of livestock breeders' income with the present activity it seems acceptable to identify a realistic increase of the revenue of breeders. The progress in genetic and artificial insemination, a good husbandry of the herds, are the main elements to justify a profit increase of at least 25% from the fourth year of project implementation due to increased production of dairy products and fatter animals with a better dressing percentage.

Table 9.3: Total profit for 7,500 ha

WAD MESKEEN IRRIGATION PROJECT				
Agricultural activities		Total value of agricultural production M° SDG	Total Production costs M° SDG	Total gross profit M° SDG
1		0	0	0
2		0	0	0
3		7 410 762	1 377 226	6 033 537
4		16 636 600	2 951 198	13 685 402
5		28 005 330	4 721 916	23 283 414
6		34 120 263	5 312 156	28 808 108
7		38 420 122	5 705 649	32 714 473
8		40 577 087	5 902 395	34 674 692
9		40 577 087	5 902 395	34 674 692
10		40 577 087	5 902 395	34 674 692
11		40 577 087	5 902 395	34 674 692
12		70 220 137	11 411 297	58 808 840
13		107 123 487	17 707 185	89 416 302
14		152 598 408	24 790 059	127 808 349
15		206 701 190	32 659 919	174 041 271
16		260 803 973	40 529 779	220 274 194
17		314 906 756	48 399 639	266 507 117
18		369 009 538	56 269 499	312 740 039
19		423 112 321	64 139 359	358 972 962
20		477 215 103	72 009 219	405 205 884
21		569 557 420	89 354 390	480 203 030
22		632 256 687	101 190 660	531 066 027
23		687 695 654	120 361 639	567 334 015
24		756 086 387	152 853 820	603 232 567
25		814 246 878	152 853 820	661 393 058
26		814 246 878	152 853 820	661 393 058
27		814 246 878	152 853 820	661 393 058
28		814 246 878	152 853 820	661 393 058
29		814 246 878	152 853 820	661 393 058
30 & Following		814 246 878	152 853 820	661 393 058

Moreover the project is located at the crossroad of livestock routes and will constitute a large reservoir of green staples for the livestock. The first estimation reveals an usual transhumance of 5.5 millions cattle heads. In addition, there are an estimated 3 millions of cattle heads than would come from northern and eastern barren areas. Quantifying in the project benefits its impact on nomadic pastoralists was not possible because of lack of accurate data. However to pass an accurate judgement on the project financial and economic viability, one must keep in mind the large induced benefits of the Wad Meskin project. Without Project the values of the present agricultural and livestock production have been taken into account. With project the existing agricultural production is gradually disappearing in favour of the new production. So the value of the existing production has been taken into consideration. Regarding livestock production the net revenue was calculated at 50.6 SDG/ha, equal to 60.6 SDG/ha gross revenue minus 10 SDG/ha production costs. In the with Project case the incremental benefit will be 25% of the present net revenue. Hence the total incremental benefit of livestock production on 107,500 ha will be 0.25 x 50.6 x 107,500 = 1.4 million SDG/year. The present value will be considered as a permanent production, always able, without or with the project, and for that it is not integrated in the project benefit.

9.2.4 Cash flow for financial analysis

The cash flow is the difference between the financial benefits and all costs of the project. The cash flow is negative for the first four years corresponding to the implementation of phase 1 without a stabilized benefit.

The investments in phase 2 are also leading to a negative cash flow during four years. After the investments phases, the cash flow is positive and increases with the growth of the profit. A more detailed cash flow is presented in the Appendix 12-8.

Table 9.4: Livestock products to implement with the project

WAD MESKEEN IRRIGATION PROJECT												
Milk Production		Nb of heads	Nb of females	Milk production kg/H	Milk production kg/H	Milk production kg/year	Farm gate price SDG/1kg	Total revenue SDG				
	Cattle	650	602	1 553	166	99 932	1.25	124 915				
	Sheep	2 100	1 955	105	17	33 237	1.25	41 546				
	Goat	1 450	1 309	125	15	19 640	1.25	24 550				
	Total							191 011				

WAD MESKEEN IRRIGATION PROJECT											
Meat Production		Nb of heads	Sold rate %	Nb Total of sold animals nb Head	Nb Animals sold alive (goat for nb Head	Farm gate price for alive SDG /H	Nb Animals sold to butchery nb Head	Farm gate price for butchery SDG /H	Nb young animals sold	Farm gate price for young	Total revenue for Meat SDG
	Cattle	650	25.0%	163			98	700	65	400	94 250
	Sheep	2 100	27.8%	584	350	150	117	300	117	160	106 252
	Goat	1 450	28.5%	413	248	180	165	110			62 814
	Total										263 316

Table 9.5: Cash flow (financial values)

WAD MESKEEN IRRIGATION PROJECT														
CASH FLOW Values: Million SDG														
	Y	1	2	3	4	5	6	7	8	9	10	11	12	13
Total value for agricultural production		0	0	7.41	16.64	28.01	34.12	38.42	40.58	40.58	40.58	40.58	70.22	107.12
Total Production Costs		0	0	1.38	2.95	4.72	5.31	5.71	5.90	5.90	5.90	5.90	11.41	17.71
Total livestock profits		0	0	0.01	0.04	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.22	0.35
Total Project profits		0	0	6.05	13.72	23.36	28.90	32.81	34.77	34.77	34.77	34.77	59.03	89.76
Investments		3.77	30.49	26.71	26.71	0.00	0.00	0.00	0.00	0.00	38.70	205.41	121.73	100.58
O&M costs		0.00	0.00	0.08	0.69	1.22	1.75	1.75	1.75	1.75	1.75	1.75	2.53	6.64
Total Costs		3.77	30.49	26.79	27.40	1.22	1.75	1.75	1.75	1.75	40.45	207.16	124.26	107.22
Cash Flow		-3.77	-30.49	-20.74	-13.67	22.14	27.15	31.06	33.02	33.02	-5.68	-172.39	-65.23	-17.45

CASH FLOW Values: Million SDG														
	Y	14	15	16	17	18	19	20	21	22	23	24	25	26 & following
Total value for agricultural production		152.60	206.70	260.80	314.91	369.01	423.11	477.22	569.56	632.26	687.70	756.09	814.25	814.25
Total Production Costs		24.79	32.66	40.53	48.40	56.27	64.14	72.01	89.35	101.19	120.36	152.85	152.85	152.85
Total livestock profits		0.47	0.60	0.73	0.85	0.98	1.11	1.23	1.36	1.36	1.36	1.36	1.36	1.36
Total Project profits		128.28	174.64	221.00	267.36	313.72	360.08	406.44	481.56	532.43	568.69	604.59	662.75	662.75
Investments		100.58	133.33	100.58	121.73	116.25	150.11	144.23	8.40	2.53	2.53			
O&M costs		9.07	11.08	13.09	15.76	17.77	20.21	22.53	25.53	28.42	28.59	28.64	28.69	28.69
Total Costs		109.65	144.42	113.67	137.49	134.02	170.31	166.76	33.93	30.94	31.11	28.64	28.69	28.69
Cash Flow		18.63	30.23	107.33	129.87	179.70	189.77	239.68	447.63	501.48	537.58	575.96	634.07	634.07

9.2.5 Main results

The first expected result is the Financial Internal Rate of Return F-IRR. It was estimated considering a 50 years long period in line with the amount of investments. The value obtained is 27.68% which is a good figure for this irrigation project dealing with a resettled population and for food security purpose. With a shorter and more usual period of 30 years for assessing the profitability of an investment, the F-IRR would be 27.26%. This confirms the project is financially viable. The most widely used measurement of the cash flow of a project is the Net Present Value (NPV). The NPV is a conventional indicator for project financial analysis. It is closely linked to project performance. When the discount rate is equal to the IRR, the NPV is zero; it is positive when the IRR is superior to the discount rate, negative when the IRR is inferior to the discount rate.

The selection of a project discount rate usually results of discussions amongst experts about financing rules (loan interest rates, bank risk and availability of self-owned funds). To keep the discussion to a minimum, International Development Partners generally require performing sensitivity tests within a range of 8% to 12%. The discount rate used for the Wad Meskeen project is 12%, consistent with the usual practices in Sudan; this would also permit comparisons with other projects in the country. The NPV value is obviously positive: 548 millions, and stresses the volume of value spread over by the project to main actors: investors, managers, farmers, suppliers, traders, IWUA's. The B/C ratio was estimated using the same discount rate of 12%. The financial analysis indicates that benefits are higher than costs; the B/C ratio is 2.5. The general rule is to go ahead with a project when the B/C ratio is above 1. The signification of a B/C ratio over 1 is that benefits are excellent. For this particular project, investments will come from public funds exclusively. Regarding the recurrent costs they should be compensated for by beneficiaries. It can be considered that the current costs of the project will be shared between the farmers and the public entity in charge of irrigation management, operation and maintenance. For doing so, farmers' capacity to pay for recurrent costs must be assessed. The opportunity cost of water is the average dynamic (real-time) cost per cubic metre or the equilibrium price of water for the considered period of 50 years. The value obtained is SDG 0.32 per m^3 if all investments and recurrent costs are taken into account and SDG 0.04 per m^3 if only recurrent costs are taken into account. The latest figure represents the actualized current costs, using 12% discount rate, per consumed m^3 of water.

9.2.6 Financial results and project management

Having identified the main results, it's then possible to consider the management style of the project and address its cash flow status. If the current costs are taken in charge by the farmers, the value of SDG 0.04 for m^3 becomes a source of funding for project management.

Generally, investments in productive assets must be financially supported during the first operation years. The Wad Meskeen irrigation project will need support in working capital for only the 13th and 14th years, and from the 22nd year, when the current expenses are stabilised at the level required for cultivating the whole project area (107,000 ha). It can be considered that, during this critical period, the need for working capital would be taken in charge by the management agency. In the other years, the irrigation fee paid by farmers would be higher than the recurrent cost provided its recovery rate is good. The working capital surplus could be transferred back to the agency. The NPV of recurrent expenses is nil at the end of the considered 50 years period. This indicates that a supplementary loan would not be necessary. The chart indicates that there is a deficit at the end of the considered period while the previous years the farmers' fees will match the current costs. Using a 12% discounting rate for a 50 years period, the difference between the respective values of the source and the needs of funds is nil. In the technical jargon, the deficit is known as intermediary charges, it results of the very nature of an investment project, and it is generally supported by the investor.

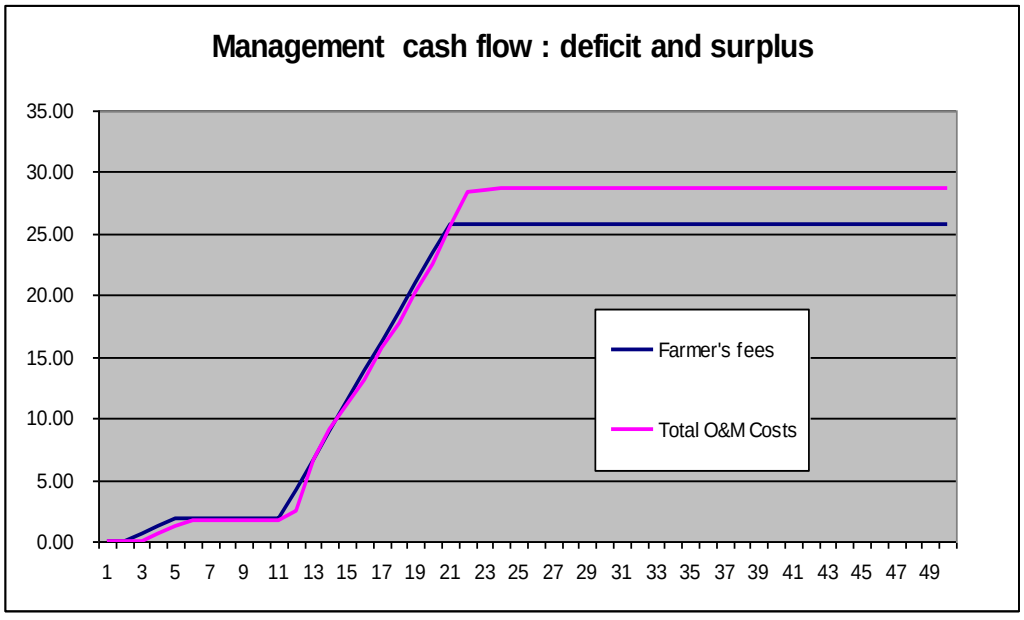
Here the intermediary charges amount to a total of SDG 83,18 millions. This gap is compensated by the surplus paid by farmers in the other years.

Table 9.6: Share of current expenses

WAD MESKEEN IRRIGATION PROJECT													
CASHFLOW Management of irrigated perimeter	SDG/m3	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Application of funds													
Total recurrent expenses		0.075	0.685	1.219	1.754	1.754	1.754	1.754	1.754	1.754	2.528	6.636	9.070
Source of funds													
Farmers' fees	0.04	0.600	1.200	1.801	1.801	1.801	1.801	1.801	1.801	1.801	4.201	6.602	9.003
Needs of working capital		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.068
Necessary surplus paid by the farmers		0.525	0.515	0.581	0.047	0.047	0.047	0.047	0.047	0.047	1.674	0.000	0.000

CASHFLOW Management of irrigated perimeter	SDG/m3	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26 & Following
Application of funds													
Total recurrent expenses		11.082	13.094	15.760	17.772	20.207	22.531	25.534	28.418	28.586	28.637	28.687	28.687
Source of funds													
Farmers' fees	0.04	11.404	13.804	16.205	18.606	21.006	23.407	25.808	25.808	25.808	25.808	25.808	25.808
Needs of working capital		0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.610	2.778	2.829	2.879	2.879
Necessary surplus paid by the farmers		0.321	0.711	0.445	0.834	0.800	0.876	0.274	0.000	0.000	0.000	0.000	0.000

Figure 9.1: Comparison between O&M costs and farmers' fees



9.2.7 Sensitivity tests

The model also enables carrying out sensitivity tests to take into account possible change in the value of project costs and benefits. Generally, sensitivity tests consider variations within a range of -10 % to + 10%, and combine several scenarios with variations of the costs and benefits to forecast the project situation for both the most optimistic and the most pessimistic scenarios.

Table 9.7: Result of sensitivity tests

WAD MESKEEN IRRIGATION PROJECT Sensibility Analysis	FIRR	B/C discount rate 8%	NPV discount rate 8%	Opportunity Cost m^3 All costs	Opportunity Cost m^3 Currents Costs
	%		million SDG	SDG/m^3	SDG/m^3
Results	27.7%	2.51	548.7	0.32	0.04
10% investment increase	25.6%	2.31	517.0	0.34	0.04
10% Total cost increase	25.0%	2.23	493.5	0.35	0.04
10% Yield decrease	24.8%	2.21	438.9	0.32	0.04
10% Farm gate price decrease	24.8%	2.21	438.9	0.32	0.04
20% Yield & Farm gate price decrease	22.1%	1.94	340.1	0.32	0.04

The figures show the strong impact of negative variations in farm gate prices and yields; the worst situation occurs when they are combined. The success of the project is therefore and not surprisingly strongly linked to the profit generated by the agricultural production. This result emphasizes the crucial role of good market organisation and efficient extension services to support farmers for production and marketing activities. Without accompanying measures related to both market organization and extension services, the project would not be viable.

The impact of variation in the level of investments is relatively limited. It is important to underline that the results show a very low sensitivity of the project to increased investment costs. Conversely, the project' sensitivity is high with respect to drops of farm gate prices and yields; the F-IRR is negative if farm gate prices or yields are only 65% of their levels in the current situation. The sensitivity analysis confirms the project is viable from a financial perspective; a F-IRR of almost 28% is a very good result encouraging to go ahead with project implementation. Using a discount rate of 12%, comparatively high, the net present value is positive. The B/C ratio has a safe value of 2.5. .

9.3 Economic Analysis

9.3.1 Methodology for economic analysis

The economic analysis assesses the contribution of an investment project to the economic growth (or GDP growth) of a country.

The economic analysis uses shadow prices to the maximum possible extent. Shadow prices are the market prices that would prevail without taxes, subsidies or policy restrictions on market activity. Project should not go ahead if its economic benefits depend on taxes or subsidies.

Table 9.8: Conversion factors applied in the economic model

WAD MESKEEN IRRIGATION PROJECT				
Farm gate price		Financial value	Economic value	Conversion factor
		SDG / qt	SDG / qt	
	Sorghum	62.5	65.6	1.05
	Groundnuts	137.5	144.4	1.05
	Sesame	237.5	249.4	1.05
	Sunflower	100.0	105.0	1.05
	Okra	100.0	100.0	1.00
	Okra export	200.0	210.0	1.05
	Melon	78.0	78.0	1.00
	Melon export	130.0	136.5	1.05
	Cucumber	32.5	32.5	1.00
	Sweet potato	70.0	70.0	1.00
	Water melon	17.9	17.9	1.00
	Rocket	80.0	80.0	1.00
	Jewsmallow	25.0	25.0	1.00
	Purslane	364.5	364.5	1.00
	Labor/ man day	20.0	14.0	0.7

The estimates of shadow prices are carried out using a conversion factor applied to the financial (market) prices excluding VAT. The conversion factors are useful to take into account the marketing costs (transportation, handling costs and commercial margins) on the basis of CIF/FOB prices to integrate export and import parity prices for each commodity. For this project shadow prices are estimated on the basis of the data given by MoA (Ministry of Agriculture). Conversion factors were used for agricultural commodities and inputs. For labour costs (SDG 20 per day for unskilled labour, and SDG 30 per day for skilled labour), the conversion factor is based on the World Bank methodology, whereby daily wage rates are reduced by a conversion factor corresponding to the rate of unemployment among the active population living in a specific project area. In the case of the proposed project area, the unemployment rate is very high, approx 70%. Cost estimates are expressed in economic prices. The labour costs are considered as opportunity costs to enlighten the change in the employment situation, and to assess the overall wealth creation at the country level. The investments are corrected on the basis of the respective share of local and imported equipments. The locally made equipments represent 30% of the total amount of investment expressed in constant SDG (value of November 2009). The conversion factor applied to the investments is 0.91.

9.3.2 Project cots

The total value of **investments is SDG 1,305 Million expressed** in economic value. The total amount is distributed in 3 main phases and on a 20 years long period. The investments are presented here with economic values, in constant prices (November 2009). These figures include 15% for contingencies. The investments consists mainly in civil works with a service life over 50 years. So renewal costs are not included in the present analysis.

The estimation of the E-IRR is made according to the same methodology as for the financial analysis. It takes into account:

- The renewal of main equipments is positioned along the time of analysis according to their normal service life.

- Operation and maintenance costs are estimated using a percentage applied to the initial value of the equipments used.

Table 9.9: Project costs

WAD MESKEEN IRRIGATION PROJECT							
Implementation program		Economic values					
	Phase1 Wad Meskeen 7 500 ha supplementary irrigation	Phase 2: Rahad 2 supplementary irrigation	Phase 3: Wad Meskeen & Rahad 2 dry season irrigation	Area with equipement ha	Area in operation Rainfed +irrig. ha	Area in operation Double cropping ha	Investments M² SDG
years							
1	Barrage Wad Meskeen & Main canal			0	0		3.43
2	Barrage Wad Meskeen & Main canal + irrigation system			2 500	0		27.74
3	Irrigation system & On-farm development			2 500	2 500		24.31
4	On-farm development & supporting investments			2 500	5 000		24.31
5					7 500		0.00
6					7 500		0.00
7					7 500		0.00
8					7 500		0.00
9					7 500		0.00
10		Barrage on Dinder river + Link canal & associated structures			7 500		35.22
11		Barrage + Link canal & associated structures + Irrigation system +on-farm equipment		10 000	7 500		186.92
12		Extension main canal + Irrigation system & On-farm development		10 000	17 500		110.77
13		Irrigation system & On-farm development		10 000	27 500		91.53
14		Irrigation system & On-farm development		10 000	37 500		91.53
15		Irrigation system & On-farm development + supporting investments		10 000	47 500		121.33
16		Irrigation system & On-farm development		10 000	57 500		91.53
17		Irrigation system & On-farm development		10 000	67 500		110.77
18		Irrigation system & On-farm development + supporting investments		10 000	77 500		105.78
19		Irrigation system & On-farm development	Roseires link to Dinder barrage + Development for double cropping	10 000	87 500		136.60
20		Irrigation system & On-farm development	Roseires link to Dinder barrage + Development for double cropping	10 000	97 500		131.25
21			Development for double cropping + supporting investment		86 000	21 500	7.65
22			Development for double cropping		64 500	43 000	2.30
23			Development for double cropping		43 000	64 500	2.30
24						107 500	
Total				107 500			1 305.27

9.3.3 Project benefits

The benefits are the value of agricultural production minus agricultural production costs. In the economic analysis, all produced agricultural commodities, either sold or consumed by the farming households are considered as economic goods. In the economic analysis, the estimates of benefits are carried out on the same principle as for the financial analysis, taking into account:

- The yields of each crop. Yields increase during the first years when farmers adopt improved agricultural practices. The economic yields are 90% of the agronomic yield to take into account losses occurring during harvest or a later stage (post harvest). The losses during harvesting and handling activities were estimated at 10% of agronomic production.

- The shadow or economic prices at farm gate;

- The shadow or economic production costs;
- A 95% cropping intensity.

The following table shows the results per ha for each crop, when the irrigation scheme is fully operational.

Table 9.10: Annual gross profit per ha, in full regime situation

WAD MESKEEN IRRIGATION PROJECT		ECONOMIC VALUES				
Resuls for 1 ha		YIELDS usable=90%	Farm gate price	Value of agricutural production	Production costs	Gross profit
		qt/ha	SDG/qt	SDG/ha	SDG/ha	SDG/ha
	Sorghum	34.0	65.6	2 231.3	778.0	1 453.3
	Groundnuts	34.0	144.4	4 908.8	657.0	4 251.8
	Sesame	20.0	249.4	4 987.5	668.0	4 319.5
	Sunflower	18.0	105.0	1 890.0	777.0	1 113.0
	Okra	140.0	100.0	14 000.0	919.0	13 081.0
	Okra export	140.0	210.0	29 400.0	919.0	28 481.0
	Melon	192.0	78.0	14 976.0	919.0	14 057.0
	Melon export	192.0	136.5	26 208.0	919.0	25 289.0
	Cucumber	400.0	32.5	13 000.0	919.0	12 081.0
	Sweet potato	380.0	70.0	26 600.0	919.0	25 681.0
	Water melon	290.0	17.9	5 191.0	919.0	4 272.0
	Rocket	168.0	80.0	13 440.0	919.0	12 521.0
	Jewsmallow	192.0	25.0	4 800.0	919.0	3 881.0
	Purslane	240.0	364.5	87 480.0	919.0	86 561.0

The results are similar to those of the financial analysis: high for vegetables and low for sorghum and sunflower. Nevertheless, sorghum is a major crop for the diet of farming households.

The livestock production is taken into account in the same way as for the financial analysis.

Table 9.11: Project gross profit (without livestock)

Agricultural activities	Total value of agricultural production	Total Production costs	Total gross profit
	M° SDG	M° SDG	M° SDG
1	0	0	0
2	0	0	0
3	7 751 431	1 244 159	6 507 272
4	17 467 098	2 666 055	14 801 043
5	29 418 856	4 265 688	25 153 168
6	35 858 891	4 798 899	31 059 992
7	40 334 689	5 154 373	35 180 316
8	42 574 397	5 332 110	37 242 287
9	42 574 397	5 332 110	37 242 287
10	42 574 397	5 332 110	37 242 287
11	42 574 397	5 332 110	37 242 287
12	73 580 119	10 308 746	63 271 373
13	112 442 791	15 996 330	96 446 461
14	160 249 822	22 394 862	137 854 960
15	217 015 685	29 504 342	187 511 343
16	273 781 547	36 613 822	237 167 725
17	330 547 410	43 723 302	286 824 108
18	387 313 273	50 832 782	336 480 491
19	444 079 135	57 942 262	386 136 873
20	500 844 998	65 051 742	435 793 256
21	597 608 242	80 721 036	516 887 206
22	663 365 764	91 413 694	571 952 070
23	721 266 337	108 732 387	612 533 950
24	793 302 929	152 853 820	640 449 109
25	854 326 231	152 853 820	701 472 411
26	854 326 231	152 853 820	701 472 411
27	854 326 231	152 853 820	701 472 411
28	854 326 231	152 853 820	701 472 411
29	854 326 231	152 853 820	701 472 411
30	854 326 231	152 853 820	701 472 411
31	854 326 231	152 853 820	701 472 411
32	854 326 231	152 853 820	701 472 411
33	854 326 231	152 853 820	701 472 411
34	854 326 231	152 853 820	701 472 411
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36	854 326 231	152 853 820	701 472 411
37	854 326 231	152 853 820	701 472 411
38	854 326 231	152 853 820	701 472 411
39	854 326 231	152 853 820	701 472 411
40	854 326 231	152 853 820	701 472 411
41	854 326 231	152 853 820	701 472 411
42	854 326 231	152 853 820	701 472 411
43	854 326 231	152 853 820	701 472 411
44	854 326 231	152 853 820	701 472 411
45	854 326 231	152 853 820	701 472 411
46	854 326 231	152 853 820	701 472 411
47	854 326 231	152 853 820	701 472 411
48	854 326 231	152 853 820	701 472 411
49	854 326 231	152 853 820	701 472 411
50	854 326 231	152 853 820	701 472 411

9.3.4 Cash flow for economic analysis

Cash flow is the difference between project benefits and project costs.

Table 9.12: Cash Flow in million SDG

WAD MESKEEN IRRIGATION PROJECT				Economic values												
CASH FLOW Values: Million SDG																
	Y	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total value for agricultura production		0	0	7.75	17.47	29.42	35.86	40.33	42.57	42.57	42.57	42.57	73.58	112.44	160.25	217.02
Total Production Costs		0	0	1.24	2.67	4.27	4.80	5.15	5.33	5.33	5.33	5.33	10.31	16.00	22.39	29.50
Total livestock profit		0	0	0.01	0.04	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.22	0.35	0.47	0.60
Total Project Profit		0	0	6.52	14.84	25.23	31.15	35.28	37.34	37.34	37.34	37.34	63.49	96.79	138.33	188.11
Investments		3.43	27.74	24.31	24.31	0.00	0.00	0.00	0.00	0.00	35.22	186.92	110.77	91.53	91.53	121.33
O&M costs		0.00	0.00	0.07	0.62	1.11	1.60	1.60	1.60	1.60	1.60	1.60	2.30	6.04	8.25	10.08
Total Costs		3.43	27.74	24.38	24.93	1.11	1.60	1.60	1.60	1.60	36.81	188.52	113.07	97.57	99.78	131.42
Cash Flow		-3.43	-27.74	-17.86	-10.09	24.12	29.56	33.68	35.74	35.74	0.52	-151.18	-49.58	-0.77	38.55	56.69

WAD MESKEEN IRRIGATION PROJECT																
CASH FLOW Values: Million SDG																
	Y	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Total value for agricultura production		273.78	330.55	387.31	444.08	500.84	597.61	663.37	721.27	793.30	854.33	854.33	854.33	854.33	854.33	854.33
Total Production Costs		36.61	43.72	50.83	57.94	65.05	80.72	91.41	108.73	152.85	152.85	152.85	152.85	152.85	152.85	152.85
Total livestock profit		0.73	0.85	0.98	1.11	1.23	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
Total Project Profit		237.89	287.68	337.46	387.24	437.03	518.25	573.31	613.89	641.81	702.83	702.83	702.83	702.83	702.83	702.83
Investments		91.53	110.77	105.78	136.60	131.25	7.65	2.30	2.30							
O&M costs		11.92	14.34	16.17	18.39	20.50	23.24	25.86	26.01	26.06	26.11	26.11	26.11	26.11	26.11	26.11
Total Costs		103.44	125.12	121.96	154.98	151.75	30.88	28.16	28.31	26.06	26.11	26.11	26.11	26.11	26.11	26.11
Cash Flow		134.45	162.56	215.50	232.26	285.27	487.37	545.15	585.58	615.75	676.73	676.73	676.73	676.73	676.73	676.73

The cash flow is negative the four fist years 4 years corresponding to implementation phase 1 without an agricultural stabilized profit. The investments in phase 2 are also leading to negative cash flow for four years. After the investments phases, the cash flow is positive and increases with the benefits. A more detailed cash flow is presented in Annex 12 (Appendix 12-9).

9.3.5 Results of the economic analysis

All indicators are good, encouraging going ahead with the project. The E-IRR is 32.1%, higher than the 12% discounting rate. Thus, the NPV is positive, amounting 645 million SDG. The B/C is more than 1, with a good value of 2.95. These results indicate the project is economically viable, it can offer employment opportunities for the current population and newcomers to the area through the development of processing, marketing and service activities. The project will strongly contribute to social peace by ensuring food security and reducing unemployment rate (Detailed results are given in Annex 12, Appendix 10, and 11).

9.3.6 Sensitivity tests

The model also enables carrying out sensitivity tests to take into account possible change in the value of project costs and benefits. Generally, sensitivity tests consider variations within a range of -10 % to + 10%, and combine several scenarios with variations of the costs and benefits to forecast the project situation for both the most optimistic and the most pessimistic scenarios.

Table 9.13: Result of sensitivity tests

WAD MESKEEN IRRIGATION PROJECT Sensitivity Analysis	EIRR	VAN discount rate 12%	B/C discount rate 12%	Opportunity Cost m3 All costs	Opportunity Cost m3 Currents Costs
	%	million birrs		birr/m3	birr/m4
Results	32.1%	645.1	2.95	0.29	0.04
10% investment increase	29.6%	616.2	2.71	0.31	0.04
10% Total cost increase	29.5%	612.0	2.68	0.32	0.04
10% Yield decrease	28.8%	529.9	2.60	0.29	0.04
10% Farm gate price decrease	28.8%	529.9	2.60	0.29	0.04
10% Yield & Farm gate price decrease	25.7%	426.2	2.30	0.29	0.04

The figures show the strong impact of negative variations in farm gate prices and yields; the worst situation occurs when they are combined. The success of the project is therefore and not surprisingly strongly linked to the profit generated by the agricultural production. This result emphasizes the crucial role of good market organisation and efficient extension services to support farmers for production and marketing activities. Without accompanying measures related to both market organization and extension services, the project would not be viable.

The impact of variation in the level of investments is relatively limited. It is important to underline that the results show a very low sensitivity of the project to increased investment costs. Conversely, the project' sensitivity is high with respect to drops of farm gate prices and yields.

The sensibility analysis confirms the project is viable from a financial perspective; an E-IRR of 32% is a very good result encouraging to go ahead with project implementation. Using a discount rate of 12%, comparatively high, the net present value is positive. The B/C ratio has a safe value of 2.9.

9.4 FINANCIAL ANALYSIS AT FARM LEVEL

9.4.1 Objectives and components

The objectives of the financial analysis at farm level are:

- To verify the food security status;
- To estimate the financial income of farming households;
- To identify the capacity of farming households for making investments;

- To estimate an acceptable level of farmers' financial participation to investment costs and at least full recovery of the recurrent costs of the project.
- To check labour availability for actually implementing the proposed cropping patterns.

The analysis is built on a "pilot irrigated farm" of 12,6 ha, following the recommendations of Ministry of Agriculture, and in order to secure a sufficient farm area allowing farmers to have a good income in the long term.

The simulation shown below uses the same cropping pattern as for economic and financial analysis, with a cropping intensity of 95% in the first phase and 133% in the third phase. The second phase is short and it is not significant at the scale of the present analysis. To assess households' food requirements an average number of 8.5 people per household was considered. According to the baseline information from FAO survey, the average annual food requirement per capita is 141 kg of cereals, 13 kg of pulses, 9 kg of oil seeds. Since the local population is used to consume vegetables, 25 kg of vegetables per capita and per year were added in the basic food requirements. The volume of production sold on the market tradable was assessed by deduction of the food requirements from the total farm production. To be on the safe side, the useful or net farm production was estimated at 90% of the total agronomic production to take into account losses occurring at harvest time and in the post harvest process. a realistic volume to sell, a first collection of production volume was done (10%) to take into account harvest, handling and storage losses. The net production available for sale on the market is indicated in the table below.

Table 9.14: Food requirement and tradable production for one 12.6 ha family farm reference scenario

WAD MESKEEN IRRIGATION PROJECT							
Pilot farm	Cropping Pattern	Cropping Pattern	Usable yields 4th Y	Total Production qt	Food requirements	Food household requirements	Gross tradable production
12.6 ha	%	ha	qt/ha	12.6 ha	c/Y	qt	qt
Sorghum	33.3%	4.2	30.6	128.4	141 kg	12.0	116.4
Groundnuts	33.3%	4.2	30.6	128.4	13 kg	1.1	127.3
Sesame	7.1%	0.9	18.0	16.1	13 kg	1.1	15.0
Sunflower	7.1%	0.9	16.2	14.5	9 kg	0.8	13.7
Vegetables	14.2%	1.8	260.2	465.5	25 kg	2.1	463.4
Forest tree	5.0%	0.6	0.0	0.0			
Total				752.9		17.1	735.8

9.4.2 The different phases

One major feature of the Wad Meskeen project is the progressive development of a large irrigated area over a more than twenty years period. It is very likely that in the course of the project the features of "model farm" will change because farmers will adapt cropping patterns to arising new opportunities and change of the market demand. However, at this stage it is not possible to predict future change in the cropping patterns. So the proposed cropping pattern is based on traditional crops that are well known by farmers and in high demand on the market. The first cropping pattern (or reference cropping pattern, for the first phase) is the one described in the financial and economic analysis, it shows a relatively large choice of crops and a well balanced proportion between food and cash crops. Cereals are predominant for food security purpose. Sorghum and groundnuts have the highest share in line with the local market demand. Forest tree areas are developed to address environmental constraints and firewood needs. The cropping intensity has a realistic value of 95%. The actual cultivated farm area is 12 ha with irrigated crops only. For the final phase of the project (or phase 3), the same crops were adopted but with a major change consisting in introducing winter crops. This will be feasible only if more water is made available. The second cropping pattern takes into account constraints related to the duration of the crop cycles and labour availability[6]. The total annual cultivated area is 16.8 ha (12 ha in summer and 4.8 ha in winter) corresponding to a cropping intensity of 133%. But to secure good yields in the long term, the production costs are twice higher than those in the first cropping pattern.

9.4.3 Results at the level of farm analysis

The simulation indicates a good result for the both cropping patterns, very satisfactory with respect to food security. Each scenario indicates a volume of tradable crops decidedly higher than the food requirements. (More details are given in Appendix 12-10). With a higher cropping intensity, the phase-3 scenario naturally provides with the highest farming income. Amongst the elements considered for the farm financial analysis, it is useful reminding that simulations were made using a labour cost of SDG 20 per day. The labour requirements are assessed on the basis of the technical crop descriptions. (Appendix 12-1, and 12-2). In the simulation, additional costs are included as Zakat fees (5% of gross profit of all crops except vegetables) according to the Islamic Law (Sharia) enforced in Sudan. The debt service is assessed using the amount of working capital (for inputs) borrowed each year at an interest rate of 15%. All results are good. This base case can now be used to assess the level of farmers' financial participation to the project. In the financial analysis, the computerised value of the farmer's fees give a good indication of their possible contribution. For one hectare the value of fees is SDG 240 equivalent to SDG 3,026 for one farm.

This amount includes the overall irrigation cost, meaning it would be the annual irrigation fee if farmers have to pay for all recurrent costs of the project. The estimated annual gross financial profit before payment of water charges of farming households shows that this cost can be supported by farmers; however in that case farmer's financial contribution to the project would amount to approx 6% for phase 1; 4.4% for phase 3. From international experience, the level of farmers' contribution should not excess 5% of the gross financial profit. Therefore, the fees seem acceptable in social terms. Moreover, irrigation development will not benefit to farming households only. A significant portion of the overall benefits will go to the off-farm sector, in particular to those who will benefit from expanded opportunities flowing from the irrigation project (the so-called multiplier effects).

[6] Farm labour is scarce in Sudan. Many rural workers seek employment in the fastly growing service and industrial sectors. In the irrigation schemes as well as in the mechanized farming areas, the production relies on migrant labour for planting and harvesting of main crops.

Therefore it is useful to assess the indirect and induced benefits of the project in order to seek how it would be possible to alleviate the financial contribution of farmers.

Table 9.15: Main results for family farm

WAD MESKEEN IRRIGATION PROJECT		Phase 1	Phase 3
Farm Result 12.6 ha			
Farm superficie	ha	12.6	12.6
Annual harvested area	ha	12.0	16.8
Crop intensity	coef	0.95	1.3
Production volumes	qt	752.9	1 054.0
Food Requirements	qt	17.1	17.1
Tradable volumes	qt	735.8	1 036.9
Gross profit	SDG	50 066.4	63 796.4
Labor man day	md	160.0	320.0
Wages amount	SDG	3 200.0	6 400.0
Gross household revenue	SDG	53 266.4	70 196.4
Debt fees (15%)	SDG	664.9	1 329.7
Zakat fees 5% (except. Veget.)	SDG	915.8	1 029.3
Estimated gross profit before project investing	SDG	51 686	67 837
Gross financial profit	SDG	48 486	61 437
Recurent costs	SDG	3 025	3 025
Net Profit	SDG	45 461	58 412

9.5 Financial Analysis of Development of 7,500 ha only at Wad Meskin

In order to assess the financial viability of development of only 7,500 ha at Wad Meskin two additional scenario's have been evaluated:

A) the full investment costs of the Wad Meskin Barrage and headworks are allocated to the Wad Meskin Project and there are no follow-on phases 2 and 3; and B) allocation of investment costs is based on proportionality, where Wad Meskin constitutes the first phase of a development of 107,500 ha, as analysed in the previous chapters. Thus, only a fraction of 7.5/107.5 of the investment costs are allocated to the Wad Meskin Project, with the remainder allocated to Phase 2 and Phase 3.

The results of the analysis are presented in Table 9.16. It can be concluded that development of Wad Meskin only is not worthwile if there is no follow-on, unless the remainder of 100/107.5 of the investment costs are considered as grant for a pilot project.

Table 9.16: Results of Financial Analysis of Development of 7,500 ha only at Wad Meskin

Scenario	Description	FIRR	B/C discount rate 12%	NPV discount rate 12%	Opportunity Cost m^3 All costs	Opportunity Cost m^3 Currents Costs
		%		million SDG	SDG/m^3	SDG/m^3
7,500 ha development						
A	full costs barrage to WM	< 0	0.50	-177.8	1.38	0.18
B	proportional costs barrage to WM	27.7%	1.99	92.5	0.35	0.05
Base		27.7%	2.51	548.7	0.32	0.04

9.6 BENEFIT DISTRIBUTION, POVERTY IMPACT AND EMPLOYMENT

The first important indicators are the F-IRR and the E-IRR. A F-IRR of 27% means a significant impact of the project on the off-farm sector, in particular on economic agents involved in marketing and transportation. Thus the primarily concerned economic agents are traders, transportation companies, inputs suppliers and service providers. A number of farmers would also develop off-farm income generating activities. An E-IRR of 32% guarantees, for a project of this nature, that the risks taken for investing in off-farm activities will be limited. The main social impact of the project is ensuring food security in the project area and in the province. For the first phase the annual production of cereals is higher than 7,600 tons while the forecasted needs for the year 2016 amount to 4,935 tons. Moreover the volumes of production of other crops such as oil seeds and pulses are largely sufficient for population needs, and would significantly increase the revenue from market transactions. In other words, the project will create jobs in the farm and the off-farm sectors and will create wealth for the households. The results underline the importance of direct jobs created or stabilised for a long period. Around 1,200 people can find permanent activities with an equivalent yearly salary over SDG 3,000, before the return of cash production sold on the markets. More than 1,500 jobs can be created in the non-farm sector and related to water management (through Iwua's), market activities (storage, transport, sale of goods), purchase cooperative activities, input providers, spare part distributors, and repair services, combining farming and breeding activities. The increase of income at the household level is well identified in the financial analysis at farm level. The figures indicate that farming households can earn an annual income of more than SDG 29 millions[7], after deduction of their labour costs.

[7] This income would serve to pay taxes, to increase the livelihood standards, to have a better access to health care and to invest in farming equipment. The annual income reaches SDG 41 millions in phase 3.

10. PROJECT IMPLEMENTATION

10.1 ORGANISATION

The implementation of the Project would be the responsibility of the Ministry of Irrigation and Water Resources. The Ministry would set-up a special Project Management Unit (PMU), that would be responsible to mobilise resources for preparation of detailed designs and tender documents, as well as for supervision of construction. The PMU would receive technical support and training facilities from international and national consultants.

10.2 TRAINING AND MANPOWER DEVELOPMENT

10.2.1 Training of staff for Main System Operator

The training requirements will have to be defined during the detailed design phase and after the modalities regarding the identification and selection of the main system operator have been formulated by the MoiWR.

10.2.2 Training on formation and capacity building of IWUAs

The objective is to develop the capacities of the staff that will be involved in establishment and capacity building activities of the IWUAs in the project area.

The capacity building activities should aim to provide WUAs with information and knowledge for carrying-out, monitoring and assessing their activities. 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, mechanisms for assessing and collecting the water supply charge, bookkeeping system, communication and conflict resolution mechanisms and so on.

Proposed supporting activities are:

- Preparation of guidelines for the formation of IWUAs and training of staff of the "supervising body"
- Preparation of a series of practical manuals on all aspects of operation and maintenance of irrigation systems (or adaptation of existing ones) and training of staff of the "supervising body" and members of IWUAs management and control committees;
- Preparation of a manual / guidelines for monitoring and evaluation of IWUAs performance supported by indicators;
- Organization of study tours to countries more advanced in the irrigation management transfer process for staff of "supervising body".

Capacity building of irrigating farmers and agricultural extension staff

The capacity building activities should address:

- On-farm water management: crop water requirements, irrigation scheduling (amount and frequency of water applications) and on-farm irrigation methods;

- Selection of cropping patterns, promotion of technology packages for irrigated agriculture, determination of farm budgets and compatibility with an irrigation cost recovery approach;
- Assessment and monitoring of the performance of irrigated agriculture: land productivity, labour productivity, water productivity and farmers' income and capacity to pay for O&M.

A set of supporting materials and training curricula should be developed accordingly.

- Arranging staffing for project implementation, including recruiting or redeploying staff with the required skills and experience, and training staff for new functions that they will have to perform;
- Organizing farmers for their participation to the project.

10.3 Detailed Design and Procurement

Detailed Terms of references for detailed design and associated studies, as well as procurement requirements and modalities have to be defined after acceptance of the final feasibility report by all stakeholders.

10.4 Overall Implementation Plan

The overall implementation of the Wad Meskin Project, including the barrage on the Rahad River has to be drawn up after acceptance of the preliminary four year implementation plan as shown in Table 9.2. This requires the participation of all stakeholders, who have at this stage very little knowledge of the proposed developments.

11. RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified:

1) The supply of water by the Rahad River during the flood season might be reduced by upstream development of projects in Ethiopia. It is not likely that irrigation in the Rahad basin will be feasible without the construction of storage reservoirs. However, if reservoirs or flood/supplementary irrigation systems are developed, the floodflows will be reduced, thus affecting supplementary irrigation negatively in the Wad Meskin Project.

2) If the nomadic tribes are not sufficiently consulted during the preparation and implementation of the Project the risk of conflicts in the future will remain high. Therefore, ths group should be integrated from the beginning of the planning process and proper mechanisms for conflict mitigation and resolution would have to be formulated and discussed with all stakeholders.

3) The availability of sufficient labour for supplementary irrigation over the full 7,500 ha.

4) If basic infrastructure and social services is not sufficiently and timely provided in the existing and new villages in and around the Project area, the risk of failure of the Project will be high.

5) With large scale farming ongoing in the area the proponent of the Project has to ensure that potential land tenure conflicts between current producers and new settlers are identified and solved transparently before Project implementation. If this is not achieved, the risk of failure of the Project will be high.

APPENDIX 1:

TERMS OF REFERENCE OF THE REVIEW OF THE FEASIBILITY STUDY AND THE PREPARATION OF DETAILED DESIGNS AND TENDER DOCUMENTS FOR THE WAD MESKIN IRRIGATION PROJECT

1. TERMS OF REFERENCE

1.1 INTRODUCTION AND OBJECTIVE

During the period 2007 to 2010 feasibility studies were prepared for the Dinger Bereha Irrigation Project in Ethiopia and the Wad Meskin Irrigation Project in Sudan. Final reports were completed by in June 2010 and submitted to the Client ENTRO who had received a grant from AfdB to finance these studies. The Client has received (applied for) a loan (or grant) from the African Development Bank Group in various currencies towards the costs of the implementing detailed design studies (hereinafter named 'the Study') for the above mentioned projects and intends to apply the proceeds to procure consultancy services for this assignment. The TOR presented below concerns only the Wad Meskin Supplementary Irrigation Project. The objective of the Study is to review the 2010 Feasibility Study (FS) of the Wad Meskin Supplementary Irrigation Project (WMSIP) of 7,500 ha net in Sudan and to provide detailed designs and specification, costs, and bid documents in accordance with the scope of works presented in the following chapters.

1.2 THE PROJECT

1.2.1 General

Wad Meskin Project is located at the Eastern bank of Rahad River (see Map 1 on following page). The Project starts at the South of Wad Meskin Village where the proposed Rahad barrage will be located and extends up the Southern boundary of Hawata Town. The northern boundary is limited by the railway line between Hawata and Gadarif the capital of Gadarif State. The Project net cultivable area lies between Hawata Town upwards Wad Meskin Village. The study area lies South of the railway line, and east of Hawata town. It covers an area of about 9,600 ha. The Project area is surounded by a number of towns mainly Hawata which lies at the northern part and tangential to the project. Faw the H/Q of Rahad I project is in the north at 70 km, Dinder Town is located at Dinder River Left bank and about 50 km away, Singa Town the capital of Sennar State is located at the Western bank of the Blue Nile and as far as 100 km from Hawata. The same applies to Sennar Town. Access is possible from many directions during the dry season, but during the rainy season roads and tracks become very often impassable and remain difficult to travel on because of the nature of the vertisols.

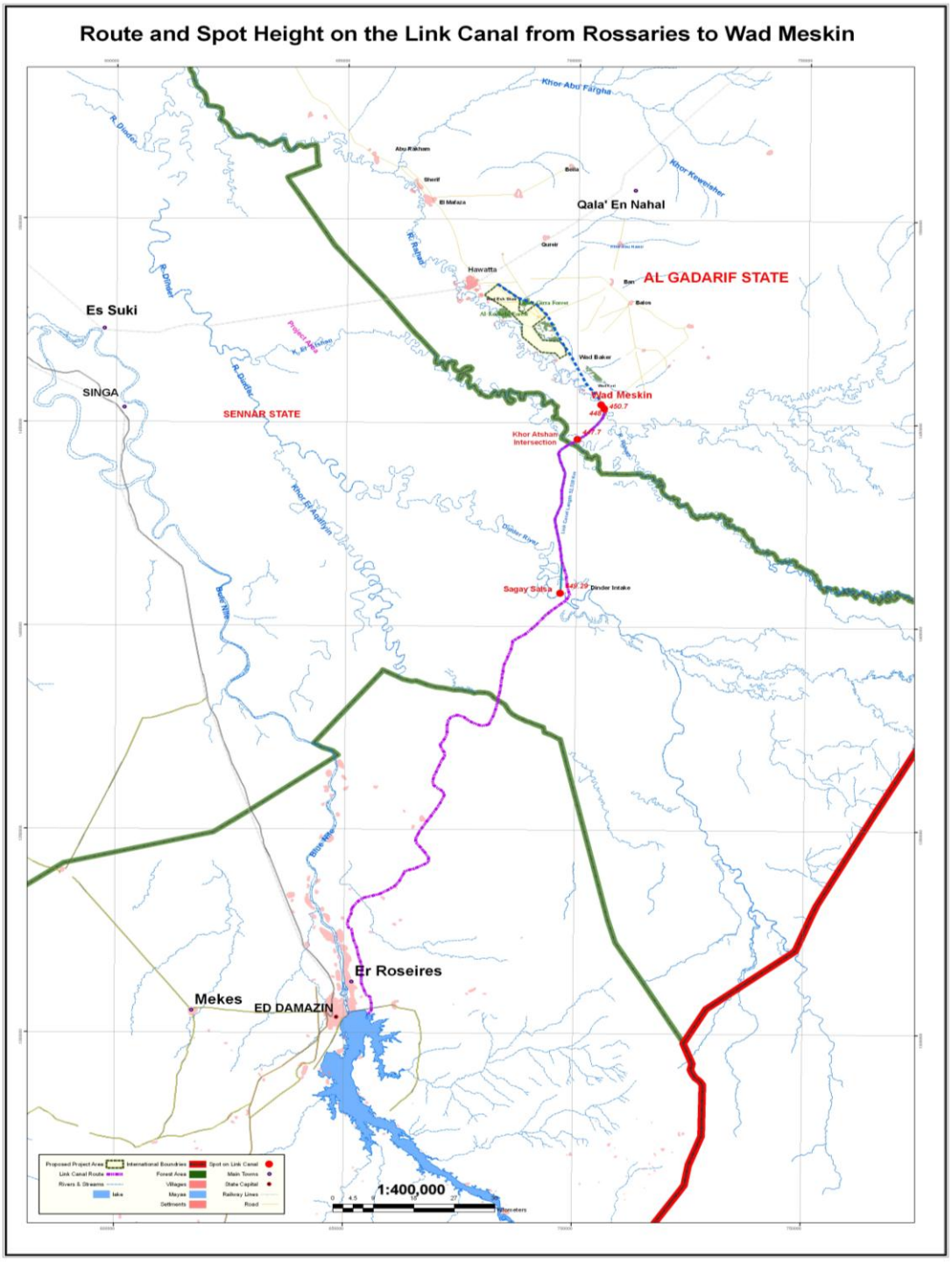
1.2.2 Identified Development Options and Project Outline

The Wad Meskin barrage across Rahad River would regulate the flood flows during the flood season, for Dinder and Rahad Rivers so as to satisfy the needs of Rahad Project Phase I, through Abu Rakham barrage as a downstream regulator, and to divert water to Rahad Project Phase II for summer crops through a main canal. This same barrage would regulate water transported from the Roseires Dam, after completion of the heightening project and the Roseires Canal, with the link canal through Dinder River barrage to the Project. The site for the proposed barrage across Dinder River has been selected. Originally a siphon was proposed to pass the Roseires canal under Dinder River. These irrigation structures "Rahad and Dinder Barrages, the link canal and the main canal" to be built at this supplementary irrigation phase are part of the requirements of the irrigation system needed after heightening Roseires dam. That is to say when the whole potential area planned to be developed "185,000 ha" is implemented. With the results of the additional investigations it was possible to prepare cost estimates and make feasibility calculations for the following scenario:

- Phase 1 would comprise the implementation of the 7,500 ha net Wad Meskin Project, the Rahad Barrage and a 10 m^3/s feeder canal. These developments are only intended to improve rain-fed agriculture.

- Phase 2 would comprise the implementation of 100,000 ha, to be irrigated with water diverted from Dinder River by Dinder Barrage to a 100 m^3/s canal linking Dinder and Rahad Rivers. The Wad Meskin feeder and main canal would be enlarged and extended.

Map 1: Location of Project area, barrage sites and link canal



- Phase 3 would comprise the construction of the Roseires Canal possibly upto the Dinder Barrage, where it would be linked to the Phase 2 conveyance system. This, however depends on whether the Mc Donald alignment of the Roseires canal which skirts the Dinder Park will be accepted by the Government. Further extension to 185,000 ha is not considered in the Feasibility Study because of wateravailability constraints in the Dinder River, but remains a possibility.

The Project works described in the following chapter only concern Phase 1 development.

1.2.3 Proposed Phase 1 Irrigation Infrastructure

1.2.3.1 Wad Meskin Barrage

The Wad Meskin barrage site on Rahad River is located upstream Wad Meskin village. At the barrage site, the river reach is narrow and straight. There are gardens on both banks. The barrage is designed to pass safely a flood discharge of 220m^3/s with a 100-year return period. The retention level is at RL 448.5, while the River bed level there is at RL 445.0. The adopted command level for Wad Meskin irrigation project is at RL 447.5. In its layout, this barrage is very similar to the already existing one at Abu Rakham. It is designed as a reinforced concrete structure with 9-gated openings, 4 m wide each in addition to a sluice way with two bays also 4 m wide each. The crest of the barrage is set at RL 446.0. The barrage is thus capable of passing the design flood discharge with an afflux of 0.30m in order to protect villages upstream from high back water effects. Energy dissipation downstream the barrage is by a USBR type III stilling basin. Water will be diverted to the irrigation project through head works located on the right bank of the barrage. The head works have a design discharge of 10m^3/s. The full supply level of the Project's main canal just downstream the head works will be set at RL 447.5. A heavy traffic road bridge will be provided to pass over the barrage and the head works. Bunds will appropriately be provided to contain floods upstream the barrage and to protect Wad Meskin village.

1.2.3.2 Wad Meskin Head Works and Main Canal System

The head works here are, in every aspect, very similar to those at Salsal on Dinder River. They will be located on the same side as, but just upstream Wad Meskin project head works. The structure is designed to pass 100 m^3/s. The main canal is designed for a capacity of 10 m^3/s, taking water from Wad Meskin proposed barrage. Experience in Sudan shows that no tail escapes are needed to cater for the safe handling of excess flow rejection. The canal would be 37.7 km long and irrigate an area of 7,743 ha. Initial bed width is 6.00 m and is reduced to 4 m at km 32.00. The volume of earthworks is about 300,000 m^3. The main canal has two major canals branching from it and is flanked by a regional road 6.00 m wide.

1.2.3.3 Major and Minor Canals and Tertiary Systems

There are two major canals, with lengths of 5.5 km and 5 km respectively. Command areas are 3,235 Feddan (1,359 ha) and 5,140 Feddans (about 2,159 ha). The total volume of earthworks is 137,400 m^3, equivalent to 13,086 m^3/km. The off take structures are of type Moveable Weir Series Two (M.W.II). There are 17 minor canals supplied by the two major canals. All off take structures of the minors are pipe regulators (P.R) of size either 0.76 m or 0.91 m. Total volume of earthworks is 543,541 m^3. The majors and minors have access roads 3.5 m wide with a 0.2 m thick surfacing. The tertiary system is of standard type used throughout Sudan and is called Abu Ishreen (Abu XX) which usually has a length of 1,350 m and spacing of 280 m. The area irrigated by an 90 Feddan or 37.8 ha. The off take structures of Abu XX are field outlet pipes (F.O.P) with standard diameters of 0.35 m.

1.2.3.4 Drainage Works

The scheme needs a cut-off drain in order to be protected from floods from outside the Project area which may wash out the canals. The scheme area needs to be drained from the excessive irrigation water and from rain water. A protective major drain is included in the canalization of the scheme. The protective drain is to direct the flow coming from the high lands to be directed to a suitable outfall to the Rahad River. The protective drain will be separated from the main canal by single bank acting like a dike. The volume of earthworks of the protective drain are 498,759 m^3 whereas its length is 47.5 km. The Project area is drained by minor drains running parallel to the minor canals executed with one section.

The total length of minor drains is 50 km and the volume of earthworks is 150,000 m^3. All minor drains are discharging in a collector that drains into Rahad River.

1.2.4 Environmental and Social Impact Assessment Issues

1.2.4.1 Methods used and Definition of Impacts

The assessment of impacts has concluded that the proposed project would be deemed as a Category 2 Project in the African Development Bank's environmental assessment procedures, for which an environmental and social assessment is required. The development of the project would be a major undertaking which cannot be limited to constructing the irrigation infrastructure, while underrating the necessary social, economical, institutional and policy framework. Paying attention to the social and environmental conditions alongside with the technical engineering can not only greatly enhance the benefits of the project for the population, but is actually crucial for its success. The environmental studies have utilised the baseline surveys made for soils, social studies, topography, agriculture, livestock, and geotechnical works. It was not possible to commission any further studies, since there was no provision in the project costs for additional staff and time. There were not enough time and resources to make detailed assessments of, for example, faunal and floral ecology including *maya* lakes, archaeology, nomadic movements. These need to be included in a detailed programme of assessment at the time of detailed design. All these types of surveys would each take several months work by various specialists.

1.2.4.2 Main impacts and mitigation planning

The assessment has shown that implementation is likely to produce both positive and negative impacts. For some impacts it is not possible to determine presently what the outcomes would be. The scale of negative impacts cannot be defined exactly at this time in a feasibility study, as these will depend on the proposals for a final detailed design for the project. During detailed design the ESIA impacts, proposed mitigation measures and the EMP should be reviewed, brought up to date , and incorporated into the final engineering designs, tenders, the client's and consulting engineer's tender supervision, and made available too to other agencies concerned with implementation. Positive impacts are likely in land use, but land take will be necessary along canals, at weirs and barrages, and for settlements and administration and will require careful consultation. In new irrigated areas biological activity will increase, and new habitats will be created that could impact on existing ecosystems; pests such as rats are likely to increase and Integrated Pest Management (IPM) will be initiated. The proximity of project works to the Dinder National Park poses serious questions on impact to fauna and flora: both positive and negative impacts are possible. The design will provide passages over canals and also access to the canal waters for wild animals. The occurrence of aquatic weed problems is likely in drains and canals if these are not maintained; impacts on the passage and traditional grazing habits of nomadic groups are likely. Their traditional rights of way along stock routes will not be impeded, though these may need slight modification.

The Project will provide grazing lands and forage production. Based on the final design, further areas where protection or compensation measures are to be established have to be specified. This will include amongst others replanting of disturbed areas, safety provision at canal crossings, safe design for structures, control wastewater from all construction, and control of aquatic weeds in the irrigation canals. The Dinder National Park might be affected by any future water resource developments in the catchment of the Dinder, within Ethiopia. The Wad Miskin area lies well within Sudan and is some 150 km, and at a much lower elevation from the Ethiopian border. It is remote from the Egyptian border far to the north. The Wad Meskin project (Phase I) will take 10 % off the peak flow from the Rahad River, and 0 % from the Dinder. The impact of this reduced flow into the Nile is considered to be minimal. In the second phase of the project, that would be for 100,000 ha of supplementary irrigation in the Rahad II area, 10% would be taken from the Rahad peak flow and max 80% of the Dinder peak flow. The downstream impacts of this on the fishing, water supply for livestock and villages, small scale irrigation, and other livelihoods along the Dinder River are likely to be significant.

Transboundary impacts are, therefore, not considered relevant in this context at this time, but any future development in Ethiopia should be careful monitored.

1.2.4.3 Environmental Monitoring

A central part of the EMP is monitoring of the project so that predicted and actual impacts can be compared. On the Wad Meskin project the key monitoring issues will be made during both construction and implementation. They are recommended to address the following as essential components: monitoring any changes in water quality, changes in soil fertility, status of aquatic ecosystems and biodiversity, changes in water related health issues, impacts on pastoralist routes, changes to traditional livelihoods, demographic trends, changes to crop production and markets. The African Development Bank (AfDB, 2003) provided a detailed list of monitoring indicators on irrigation projects, under the general headings of poverty, environment, population, health outcomes, gender and participation. The management of future Wad Meskin project would follow these guidelines on a regular basis. Technical and non-technical issues would be the responsibility of the relevant department of the project (administration, engineering, water supply, health and safety, agriculture ; transport; settlements etc). Other data is already collected in the area by the Locality departments in Hawata and the projects would need to come to data-sharing agreements with these organisations. Estimates of the frequency of monitoring activities within each section have been prepared and can be found in the Main Report of the FS.

1.3 Phase 1: Review of Feasibility Study and Implementation of Additional Studies

1.3.1 Irrigation System Development

Based on the information obtained from the feasibility study regarding the lay-out of the conveyance and distribution systems, the following design aspects shall be addressed in close consultation with the farmers and Government staff:

- Review the advantages and disadvantages of the proposed irrigation system and compare with alternative systems, calculate the investment and recurrent cost of each alternative. Based on the initial investment, operation and maintenance costs and also the simplicity of operational management, recommend the most appropriate irrigation system.

- Taking into account the detailed recommendations of the FS, identify the most appropriate in-field irrigation application system(s) with respect to topography, soil type, water use efficiency, irrigation management, reliability and cost of the material supply, as well as farmers' acceptance and management capacity. The FS recommended to adopt the classical distribution system.

- Prepare lists and specifications of irrigation materials and calculate their associated costs.

1.3.2 Agricultural Land Development

Based on the information obtained from the feasibility study of soils, topography and also data from the existing cropping patterns, the following agricultural issues shall be addressed in close consultation with farmers and MoA staff:

- Prepare detailed cropping patterns, crop husbandry and other factors affecting yields, supplementary irrigation practice and land use efficiency.

- Work out irrigation calendars per growth stage, soil type and season in conformity with the selected irrigation system.

- Define agricultural practices to be adopted in the light of the soil, topographic and climatic data.

- Define the equipment required for land development and calculate associated costs.

- Prepare lists and specifications of agricultural machinery, implements and workshop tools necessary for the development and determine associated costs.

- Estimate the total investment cost of the agricultural development and the annual operation costs including fixed costs and variable costs,

1.3.3 Mapping

- Carry out surveys to establish current boundaries of landholdings of individual farmers.

- Prepare cadastral maps that indicate these boundaries and compile data on GIS system, using the topo maps prepared during the FS.

- Using the cadastral and topo maps, determine exact routes and locations of structures.

1.3.4 Infrastructure

- Determine detailed infrastructure requirements for project management organization, power supply, communications, roads and drainage structures, with all necessary facilities. These shall be worked out and an implementation schedule would be made available.

- Present engineering estimates of costs for the infrastructure.

- Prepare implementation and cost allocation schedules.

1.3.5 Manpower Requirement

Present the detailed manpower needs to manage, operate and maintain the irrigation scheme and to provide support to the farmers and give a breakdown into skilled (specify), semi-skilled, and unskilled personnel.

1.3.6 Creation of Water User Organizations

Using the recommendations of the FS and in close cooperation with farmers leaders and MoA staff the Consultant will start organizing farmers in Water Users Organizations and will prepare detailed training programmes to ensure capacity building at all levels.

1.3.7 Environmental and Social Impact Assessment (ESIA)

During the feasibility study in 2008 and 2009 a preliminary ESIA was carried out that included a broad assessment of the environmental effects of the proposed Project. This study identified specific environmental control measures in and around the proposed facilities but identified a host of other issues that could not be studied in detail.

The additional ESIA during the detailed design phase shall include land use, soil conservation, forestry, environmental pollution and control requirements, as well as other issues identified in chapter 1.2.4 of these ToR. Moreover, a detailed environmental management plan (EMP) and resettlement action plan (RAP), if necessary, will have to be formulated as soon as designs have become more detailed and consultations with stakeholders have been carried out. Associated costs will be incorporated into the overall project costs to ensure compliance with all statutory guidelines.

1.4 PHASE 2: DETAILED ENGINEERING DESIGNS AND PREPARATION OF TENDER DOCUMENTS

1.4.1 General

The Consultant shall prepare detailed designs including all required drawings on the basis of the results of the review and on the detailed design criteria. The drawings shall be based on engineering investigations and calculations and the results of EIA, EMP, and any required RAP carried out during Phase 1.

The drawings will be prepared with sufficient degree of detail, including required information allowing for performance of good quality construction and accurate definition of quantities of the works. On the basis of the detailed design a list of drawings, including site plans (in scale to be defined with ENTRO and executing Ministry) shall be prepared and presented in the a Detailed Design Report. The required detailed data on presentation, kind, number and scale of drawings will have to be identified during Phase 1, in close consultation with ENTRO and the executing Ministry. The work content and quantities shall not consider attendant measures, connected with organization of construction and technological schemes of works performance, testing, and putting into operation works of electro-mechanical and hydro-mechanical equipment besides those specified in the design as obligatory. All construction design drawings and quantity tables for equipment testing must be submitted with the Confidential Engineering Estimates.

In general, the following principles must be taken into account during the design of the head works, canals & drains, and structures:

- Hydraulic and structural design must be transparent and must meet internationally accepted standards.
- Structures must be designed according acceptable safety standards, ensuring their stability under all circumstances and preventing harm and damage to living creatures.
- The design of the headworks must be based on maximum flood estimates and subsurface hydraulic analysis, using the hydrological, the geological and geo-technical information presented in the FS.
- Operation and maintenance of the components in the system must be as simple as possible, durable and not prone to interference by non-authorised persons.

1.4.2 Technical Specifications

The Consultant shall develop the construction technical specifications in close coordination with the executing Ministry. The technical specifications shall contain detailed descriptions of regulations and terms of works performance, as well as standards of materials and quality of goods and services. Standard technical specifications of the executing Ministry will include all main types of civil works. These shall form the basis for preparation of the construction technical specifications.

They do not exclude occurrence of new issues or types of works or use of materials in the process of construction, which were not included in the Standard Technical Specifications, but should be defined in technical terms. In case of such issues they shall be prepared by the Consultant. Technical Specifications shall be adjusted individually to each construction package. It means that for each contract some items can be added or excluded. At the end the Technical Specifications include as "Attachment" documents providing continuity of construction process as: Bill of Benchmarks, appropriate environmental clauses from design/scheme level EIAs, agreements with and permits from appropriate organizations (Ministries, Environmental Protection Agency, Energy etc.), with institutional organizations on electricity transmission lines, crossings with highways; location of reserve and spoil banks, land alienation and other agreements.

1.4.3 Bill of Quantities and Planning of Civil Works

Planning of civil works shall include all works of the selected option considering the duration of the cultivation season, rainy season conditions and actual estimation of time and methods of construction. In conformity with planning of civil works, the Consultant shall prepare the Engineering Estimates of Quantities. These quantities shall be filled in a table, hereafter called the Bill of Quantities (BOQ), which is to be included in the Bidding Documents.

Consultant shall prepare a simplified BOQ with reduced but sufficient number of "descriptions" (items) of work and reasonable working out of quantities in details. BOQ shall consist of Summary BOQ and separate parts of BOQ (earth works, concrete works, metal works etc.), submitted on separate sheets and agreed with ENTRO and the executing Ministry. The Consultant shall submit the table of conformity of BOQ with items of quantities on drawings in "General Attachments". The BOQ shall not include quantities associated with organization of construction, with technological schemes and putting into operation, except those specified in the design as obligatory. In the bidding documents will be included the final EIA, EMP and RAP (if any) as well as any required technical, environmental and social permits and approvals. According to this TOR the Consultant is responsible for technical aspects of the bidding document, including the Bills of Quantities, Technical Specifications, Confidential Cost Estimate, inputs relating to the environment and economic analysis. ENTRO and the executing Ministry will be responsible for issuing the complete Invitation for Bid.

1.4.4 Preparation of Confidential Engineering Estimates and General Attachments

The Consultant shall develop Confidential Engineering Estimates of the construction costs (including mitigation measures costs) and submit them separately to the Client. The Consultant shall not disclose these estimates to others, particularly to potential contractors and/or suppliers. The Confidential Engineering Estimates of Construction Costs shall provide the Client with a point of reference for financial planning and control. Confidential Engineering Costs shall be prepared according to real market prices, which shall include subtotals according to relevant sections of summary BOQ. The General attachments shall include materials not connected directly with the construction process, such as:

- Terms of Reference;
- Defect Lists;
- Minutes of Meetings;
- Conclusions (on tests of materials, structures etc.);
- Letters;
- Table of conformity of BOQ items to items of quantities on drawings;
- Table of conformity of BOQ items to items of market prices;
- Other materials worked out in the process of designing.

1.4.5 Completion of Phase II

Phase II shall be completed with the preparation and the subsequent approval by ENTRO and executing Ministry of the Bidding Documents and Confidential Engineering Estimates. The period for the review and approval of the Bidding Documents by an independent Expertise shall be included in the overall duration of design. The Expertise services costs are covered by Consultant and shall be provided for in the Financial Proposal. It is assumed that the entire expertise process will last about 30 days, i.e. Consultant shall submit 10 copies of the above documentation to ENTRO for review, making corrections and approval 30 days before the design deadline.

The Consultant shall submit to ENTRO the following:

- Bidding Documents consisting of:
    - Technical Specifications - 10 copies.
    - Drawings (in 2 separate files for each canal) - 10 copies
    - Final EIA, EMP and RAP (if any) - 10 copies.
    - Any required technical, environmental and social permits and approvals (10 copies).
    - Bill of Quantities – 10 copies.
- Attachments
    - Confidential Engineering Estimates - 2 copies.
    - General Attachments - 2 copies.

1.4.6 Detailed design criteria

Design criteria need to be formulated and agreed upon BEFORE proceeding to the detail design task, so this will have to be carried during the latter part of Phase 1. They will be presented in a Design Criteria Report to be submitted not later than the Phase 1 Report.

1.4.7 Terms of reference for support to Client during bid evaluation and supervision of construction

The Consultant will be responsible to prepare detailed Terms of Reference for support to the Client during evaluation of the bids for construction and for supervision of construction.

1.5 EXPERTISE REQUIREMENTS

1.5.1 General

To undertake the Study ENTRO will engage the services of a consulting firm or firms through requirement procedures as stipulated in AfDB's guidelines on selection of consultants. It is anticipated that a total of 90 person-months of professional staff will be required comprising 40 person-months of International professional staff and 50 person-months of National professional staff. Further, about 15 person-months of sub-professional staff and technical staff and 15 person-months of supporting staff will be required. The review and design studies will be undertaken by a team of experts comprising International and National professional staff. In general, preference will be given to International staff that has work experience in Sudan and/or in the region. The expected requirements for professional staff and qualifications are shown in the next chapter.

1.5.2 Required Number of Manmonths

The following table shows the approximate number of personnel and total manmonths for each position of international and national Professional staff.

	Designation	nr	Mm/ person	Total nr of mm
International Professional Staff				
1	Team leader/Irrigation Engineer	1	10	10
2	Geotechnical Engineer	1	2	2
3	Irrigation and Drainage Engineer	1	2	2
4	Hydraulic Engineer	1	10	10
5	O&M specialist	1	1	1
6	Structural Design Engineer	1	10	10
7	HM&E Engineer	1	2	2
8	Water User Association Specialist	1	2	2
9	Environment Specialist	1	1	1
	subtotal			*40*
National Professional Staff				
1	Deputy Team leader/Irrigation Engineer	1	10	10
2	Topographical Engineer	1	4	4
3	Geotechnical Engineer	1	2	2

4	Irrigation Design Engineer	1	2	2
5	Hydraulic Design Engineer	1	4	4
6	Irrigation and O&M Engineer	1	2	2
7	Structural Engineer	1	10	10
8	HM&E Engineer	1	4	4
9	Contract Engineer	1	6	6
10	Environment Specialist	1	2	2
11	Sociologist/Public Participation Specialist	1	4	4
	subtotal			*50*

The total number of man-months amounts to 90. The Professional staff will be supported by technical staff (CAD and GIS technicians, secretaries), which require about 30 manmonths.

1.5.3 International Professional Staff

(1) **Team Leader/Irrigation Engineer**: should be a university graduate civil engineer with about 20 years experience in the field of preparing feasibility studies and detailed designs of irrigation projects. He/she should also have experience in operation and design of irrigation systems, and maintenance of infra-structure projects. He/she should have preferably worked in Sudan and/or in the region in the field of water resources planning, operation and design of major irrigation systems. Further he/she should have experience in management of a multi-disciplinary team for a minimum period of 10 years and be capable of concise reporting. His/her duties will include all duties normally assigned to a team leader such as liaison with ENTRO and the executing Ministry and other Sudanese institutions, liaison with and reporting to his/her home office, coordination of the feasibility, design and investigation work, overall responsibility for administrative, financial, and technical reporting, progress planning and overall guidance to the professional and supporting staff.

(2) **Geotechnical Engineer**: should be a university graduate with about 15 years experience in planning of geotechnical investigations, collection and analysis of geotechnical data for design and construction of embankments, canals & drains, foundations for weirs, headworks and other water related structures. His/her duties will also include preparation of a subcontract for geotechnical field investigations and soil laboratory testing, supervision of such investigations and testing and interpreting borelogs and soil parameters.

(3) **Irrigation Engineer**: should be a university graduate with about 15 years experience in water resources planning. He/she should have experience in planning of water availability, water demand for irrigation, distribution schedules and in designing surface irrigation systems. Preferably, he/she should have worked in Sudan and/or in the region in the field of water resources planning.

(4) **Senior Hydraulic Engineer**: should be a university graduate with about 15 years experience in planning and hydraulic design of large conveyance systems such as irrigation canals and pipe lines including appurtenant hydraulic structures as weirs, siphons, water level control and measuring structures, culverts, etc. Further, he/she should have experience in preparation and running of hydraulic canal models.

(5) **O&M Expert**: should be a university graduate with about 15 years experience in the O&M of irrigation and drainage systems. He/she should have experience in the planning of O&M, improvement of irrigation and drainage system operation and its management.

(6) **Senior Structural Design Engineer**: should be a university graduate with about 15 years experience in planning, detailed design, and construction of structures in diversion, conveyance and distribution systems such as weirs, siphons, intake and outlet works, regulators, retaining walls, modular offtakes, bridges, etc. He/she should have profound knowledge of detail design of water retaining structures and construction planning, including preparation of design and tender drawings. His/her duties will be to plan and prepare detailed designs of the major structures, execute design calculations, prepare the relevant specifications and guide the National structural and civil engineers in their design work, preparation of the bill of quantities, cost estimate and design and tender drawings.

(7) **Hydro-Mechanical and Electrical Specialist**: should be a university graduate with about 15 years experience in planning, design, installation and operation of hydro-mechanical and electrical (HM&E) equipment used in water resources infrastructures such as trash racks, hydraulic gates, measuring gates, spillway and flushing gates, etc. Further, he/she should also have experience in preparation of specifications for procurement and testing of HM&E equipment.

(8) **Water User Association Specialist**: should be a university graduate with about 10 years experience in agriculture water management and organizing farmers in water management projects. He/she should have experience. He/she should preferably have experience in Sudan and/or in the region.

(9) **Environment Specialist**: should be a university graduate with environmental background and not less than 15 years experience in environmental impact assessment (EIA), and Environmental Management Planning (EMP) of water resources development and related projects. This shall include experience in environment impact and in the assessment of resettlement and compensation. He/she must have experience in the preparation of Environment Impact Assessment reports according to the national guidelines. He/she shall be assisted by the national Sociologist/Public Participation Specialist.

1.5.4 National Professional Staff

(1) **Deputy Team Leader/Irrigation Engineer:** should be a university graduate civil engineer with about 15 years experience in the field of water resources planning, feasibility studies, design and construction of irrigation and drainage systems and related structures and raw water supply. Further he/she should have ample experience in managing project teams for design studies. His/her duties will include liaison with the Team Leader as well as his own home office, preparation of coordination with various local authorities and survey and investigations contractors, overall guidance to the National staff members, reporting on special subjects to the Client and participation in feasibility, design and construction work.

(2) **Topographical Engineer**: should be a university graduate with about 10 years experience in collection and review of topographical data, measurement of cross sections and levelling, preparation of contracts for topographical surveys and supervision of field work. He/she will be responsible for planning of the survey work, its supervision and preparation of survey data and maps for detailed design. His/her duties will further include quantity estimation of canal&drain excavation, cadastral mapping and determination of the location and dimensions of cross regulators, irrigation offtakes and other important canal structures.

(3) **Geotechnical Engineer**: should be a university graduate with about 10 years experience in geotechnical aspects of foundation design and construction of hydraulic structures and siphons as well as in the design of canal banks and in unstable soil. Further, he/she should have ample experience in analysis of materials used for fill and foundation of hydraulic structures and supervision of geotechnical field investigations and laboratory testing.

(4) **Irrigation Design Engineer**: should be a university graduate with not less than 10 years experience in planning and design of surface irrigation and drainage systems. He/she should also have knowledge of operation and maintenance of irrigation canals, reservoirs, and related control and measuring structures.

(5) **Hydraulic Design Engineer**: should be a university graduate with about 10 years experience in hydraulic design of irrigation and drainage canals and appurtenant structures such as barrages, headworks irrigation offtakes, etc.

(6) **Irrigation and O&M Engineer**: should be a university graduate with not less than 10 years experience in planning of O&M requirements (equipment, manpower, maintenance intervals) for irrigation and drainage systems. Further, he/she should have experience in investigation and implementation of operation improvement measures for: large conveyance systems, including water level control, flow measurement and maintenance of sediment traps.

(7) **Structural Engineer**: should be a university graduate with not less than 10 years experience in structural design and construction of hydraulic structures such as weirs, siphons, spillways, culverts, and irrigation offtakes as well as in the design of roads and bridges. His/her duties will be preparation of detailed designs of canal structures and improvement works, relevant specifications and structural design and tender drawings.

(8) **Hydro-Mechanical and Electrical Specialist**: should be a university graduate with about 15 years experience in planning, design, installation and operation of HM&E equipment used in water resources infrastructures, such as trash racks, hydraulic gates, measuring gates, flushing gates, etc. Further, he/she should also have experience in preparation of specifications for procurement and testing of HM&E equipment.

(9) **Contract Engineer**: should be a university graduate with about 10 years experience in preparation of prequalification documents, tender documents and schedules for construction works. He/she should also have experience in preparation of tenders and contracts for International Competitive Bidding (ICB) and National Competitive Bidding (NCB).

(10) **Environment Specialist**: should be a university graduate with environmental background and not less than 8 years experience in environmental impact assessment (EIA) of water resources development and related projects. This shall include experience in environmental impact and in the assessment of resettlement and compensation. He/she must have experience in the preparation of Environment Impact Assessment reports according to national guidelines. He/she will assist the international Environmental Specialist.

(11) **Sociologist/Public Participation Specialist:** should be a university graduate in social geography or spatial planning with not less than 8 years experience in the field of regional development planning, assessment of social impacts of water resources development and related projects and in public participation activities. Further he/she should have experience in identification of socio-economic problems related to settlement, preparation of resettlement plans and compensation arrangements. He/she will assist the international Environmental and WUA specialists.