ENTRO

EASTERN NILE POWER TRADE PROGRAM STUDY

AfDB

PRE-FEASIBILITY STUDY OF MANDAYA HYDROPOWER PROJECT, ETHIOPIA

FINAL INITIAL ENVIRONMENTAL IMPACT ASSESSMENT

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with participation of :

- EPS (Egypt)
- Tropics (Ethiopia)
- YAM (Sudan)

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List of Acronyms and Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
BCM	billion cubic metres
BMP	Best Management Practice
BoARD	Bureau of Agriculture and Rural Development
BoFED	Bureau of Finance and Economic Development
BRDA	Benishangul Gumuz Rehabilitation and Development Associations
CO_2	carbon dioxide
CRA	Cooperative Regional Assessment
CSA	Central Statistical Authority
EFAP	Ethiopian Forestry Action Programme
EIA	Environmental Impact Assessment
El.	Elevation
EMP	Environmental Management Plan
ENSAP	Eastern Nile Subsidiary Action Programme
ENTRO	Eastern Nile Technical Regional Office
EPA	Environmental Protection Authority (Ethiopia)
ETB	Ethiopian Birr
EW&NHS	Ethiopian Wildlife and Natural History Society
EWCO	Ethiopian Wildlife Conservation Organization
FGC/M	Female genital cutting/mutilation
FGD	focal group discussion
FSL	full supply level
GIS	Geographic Information System
GWh	gegawatt hour
ha	hectare
HH	household
HPP	hydropower project
HTP	Harmful Traditional Practices
IBA	important bird area
IEA	initial environmental assessment
ITN	Insecticide treated mosquito net
kg	kilogram
km	kilometre
LSU	livestock unit
m	metre
masl	meters above sea level
MIWR	Ministry of Irrigation and Water Resources (Sudan)
mm	millimetre
Mm^3	million cubic meters
MoA	Ministry of Agriculture (Ethiopia)
MoFED	Ministry of Finance and Economic Development
MOL	Minimum operating level
MoWR	Ministry of Water Resources (Ethiopia)
MWRI	Ministry of Water Resources and Irrigation (Egypt)
MW	Megawatt
NBI	Nile Basin Initiative
NFPA	National Forest Priority Area (Ethiopia)
NGO	Non-government Organization

NP	National Park
NTFPs	non-timber forest products
PA	Peasant Association
PAP	Project Affected People
RDO	Rehabilitation and Development Organizations
RECC	Regional Environmental Co-ordination Committee (Ethiopia)
RIS	Regional Information System
STDs	sexually transmitted diseases
UNHCR	United Nations Higher Commission for Refugees
URT	Upper respiratory tract infection
USD	United States Dollar
WBIPP	Woody Biomass Inventory and Strategic Planning Project

Ethiopian Words Used in the Report

Abbay River	Blue Nile river in Ethiopia
Abbay Basin	Nile sub-basin in Ethiopia
Amhara	Amharic-speaking people, principal inhabitants of the Amhara Region part of the Abbay Basin
Border & Mandaya	Local names for two hydropower dam sites
Feluco	Small locally made boat in Benishangul Gumuz used to cross the Abbay river
Kebele	small local government unit, approximately equivalent to one village (in the rural area it is equivalent to peasant association)
Oromo	indigenous people of Oromia; principal inhabitants of Oromia Region; it is partially extending to the Abbay Basin
Woreda	local government unit comprising a large group of villages, which is equivalent to district in some other countries
Feda	Traditional hunting ceremony of Gumuz people in Benishangul Gumuz Region
Idir	Voluntary association in a community mainly established to provide assistance at a death in a member family.
Iqub	Voluntary associations in a group of people where each member raises a fixed amount of money periodically where the total collected is given to each member in turn and revolving until all members get the allotted amount of money once before it terminates
Birr	Ethiopian Currency
Kola	Low land below 1,500 masl
Weina Dega	Climatic zone between 1,500-2000 masl
Dega	Climatic zone above 2500 masl

E.1 EXECUTIVE SUMMARY

E1.1 INTRODUCTION

The Mandaya project is located in Ethiopia at the head of an existing and developing hydropower cascade on the Blue Nile and Main Nile in Sudan and Egypt. The project is therefore on an international waterway and impacts on three countries (Figure E.1).

The energy produced by the 2000 MW Mandaya project (12,119 GWh/year), and the uplift in energy at hydropower facilities in Sudan (2,211 GWh/year), resulting from Mandaya's regulation of the river and substantial raising of dry season flows, will make very valuable contributions to economic development in the region. These energies may be valued at close to USD 450 million and USD 90 million per year, respectively. The energy generation is expected to be sustainable for many years, and many more years than necessary to recover development costs. The long-term sustainability of the project's energy generation and the energy uplift in Sudan requires implementation of watershed management measures in the Abbay catchment area. Plans for these are under development.

The engineering of the project has been studied at pre-feasibility level. None of the key engineering parameters of the Mandaya project have been optimised. Optimisation awaits a feasibility study. Initial examination of the engineering project as currently presented indicates that the project will have many secondary benefits and that its adverse impacts are all capable of mitigation provided national and World Bank safeguard policies are rigorously pursued.

All project-related countries share the Nile Basin Initiative's vision of promoting sustainable and equitable development in principle, including promotion of power trading providing, *inter alia*, that energy tariffs compete with alternative sources. Owing to the size of the proposed dam and long construction period, the earliest year that Mandaya could become operational would be 2021. Depending on river flow conditions in subsequent years and downstream release requirements during the first filling of the reservoir, it is expected to be a further three years or so before Mandaya is operational at maximum output.

E1.2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

There appears to be no policy, legal or administrative obstacles to the development. The policy and legal instruments in Ethiopia and Sudan are conducive to development of more energy projects in the interests of national development goals, and provide the safeguards required for environmental and social protection and mitigation of adverse impacts. The recently implemented Gilgel Gibe hydropower project by EEPCO in Ethiopia has been acclaimed for successful implementation of national and international safeguard policies with regard to environment protection and resettlement. This recent history lends great support to successful promotion of Mandaya and other hydropower projects on the Abbay river.

Figure E.1 : Location of Mandaya, Border and Dal Sites

The Mandaya project will trigger several World Bank safeguard policies, namely Environmental Assessment, Projects on International Waterways, Involuntary

Resettlement, and Dam Safety. It may also trigger safeguard policies on Natural Habitat, Forests and Physical Cultural Resources but it appears not to trigger safeguard policies on Indigenous Peoples, Pest Management or Projects in Disputed Areas.

E1.3 EXISTING ENVIRONMENT

The biological database of the Mandaya project area in terms of terrestrial and aquatic ecology is generally poor or very poor, though better for fish. It is a vast wooded area with very small areas of cultivation and has never attracted sustained detailed field studies. Communications within the area are rudimentary, making surveys difficult. As Ethiopia is endowed with rich floral and faunal resources, and possesses some of the richest endemic fauna and flora in the African continent, resulting from the immense topographic and climatic diversity in the country, it may be expected that detailed surveys of the project over a considerable period of time would produce impressive lists of plant and animal species. Such surveys will be required because baseline information is not sufficient for comprehensive impact assessment. However ecologists, at this scoping level, following site visits, literature reviews and consultations with other professional ecologists and local people, record that among the reported species of mammals, birds and aquatic life, none are recorded to be endemic to the project area and none are critically threatened. There is therefore, at this stage, no known impediment with regard to terrestrial or aquatic ecology to proceeding to more studies of the project. Nevertheless, because the database is so incomplete and rare species, with restricted range distributions, are not easily sampled and brief surveys can easily miss these species, future studies must include generous provision for detailed ecological surveys. It is considered that these surveys will take a minimum of two years.

The Mandaya dam site and reservoir area (736 km^2) is close to but does not encroach on the Dabus Valley Controlled Hunting Area (1,227 km^2). Information about the wildlife habitat and wildlife of this area is scanty, and it is understood to be a part of the 84% of protected areas in Ethiopia that are unmanaged. It has therefore been proposed that future detailed ecological surveys include this area, and that the Mandaya project considers its adoption, with a sustainable environmental management and monitoring plan, as an environmental offset for the loss of wildlife habitat and wildlife in the project's reservoir area. Such surveys would also contribute markedly to the Ethiopian Wildlife and Natural History Society that wishes to determine the status of the Dabus Valley area regarding its future designation as an Important Bird Area.

The population of the project-affected area in Benishangul Gumuz and Amhara regions comprises several ethnic groups, including the Gumuz. The population is principally engaged in cultivation, with some livestock. Other activities relate to those typical of rural areas – non-timber woodland products, trading, etc. The population density is low and the people are among the poorest in Ethiopia, with more than half having incomes less than USD 1 per day. Regional government's provision of services in the area in terms of road communications, water supply, sanitation, education and health are basic, handicapped by the immense geographical area with its dispersed population. It is estimated that some 600 persons (122 households) live in the reservoir area and will require compensation and resettlement. A larger number (1,020 persons in 204 households) live in areas generally affected by project construction activities and, until detailed studies refine impact areas, compensation and resettlement costs have been included in provisional budget estimates for them also. Owing to regional government's difficulties in providing adequate infrastructure and services to communities in the area, government-led resettlement is already taking place and more is planned, though not necessarily for all the communities which would be affected by the project.

Some small areas of flood recession agriculture are cultivated in the reservoir basin by families living outside of the area. These, and other lost resources, have been assessed and included in compensation and mitigation measures.

Preliminary social and archaeological assessment of the project-affected area in Benishangul Gumuz and Amhara regions has not revealed physical cultural resources. As with ecology, past research has been at a basic level. Additional surveys are required in future studies.

The project's downstream impacts are hydraulic, hydrological and morphological, and relate to the uses made of the lower Abbay, Blue Nile and Main Nile. These are principally hydropower, irrigation, water supply, fisheries, river communication facilities and flood recession agriculture as far north as Lake Nasser/Nubia where flows of the Main Nile are stored in Lake Nasser/Nubia behind High Aswan Dam. Apart from the many benefits of the Nile in this desert reach, periodic flooding causes major disruptions to community and farming activities and much damage to properties and infrastructure, whilst seasons of poor rainy seasons in the Ethiopian Highlands produce low Nile discharges, low power generation, reductions in commanded irrigation areas, reduced production from flood recession agriculture and food security crises – particularly in Nile and Northern states. Lake Nasser/Nubia, apart from its primary regulatory functions for power generation at Aswan and water supplies to almost all of Egypt north of it, supports fisheries and agriculture (lake recession agriculture and irrigation by pumping) and is a local means of communication in the lake area as well as providing ferry services for the international link between Wadi Halfa and Aswan.

Downstream of High Aswan Dam in Egypt, which became operational some 40 years ago, flows of the Nile are completely regulated. These have generally made Egypt secure in water and food supply over these years and the acute problems of extreme floods and extreme low flows along the Nile from Aswan to the delta, as described for Sudan above, a distant memory. Nevertheless, experience of the prolonged drought of the 1980s, when Lake Nasser/Nubia dropped to previously unrecorded low levels, remains foremost in the minds of water resources planners in Egypt and it is for this principal reason that there is great concern about how proposals for water-related projects upstream will impact on Egypt's life line.

E1.4 PRINCIPAL IMPACTS, MITIGATION AND ENHANCEMENT MEASURES

E1.4.1 Construction – bio-physical impacts in Ethiopia

Construction of the Mandaya project is expected to take ten years. Mitigation of the bio-physical impacts of the project in Ethiopia, following detailed assessment of these in a future EIA study, will require conscientious attention to planning and implementing environmental protection measures for every aspect of construction.

There is no reason currently to believe that mitigation measures cannot be successfully implemented.

It is suggested that compensation for loss of woodlands and wildlife habitat be provided by the project giving pro-active support to the ecological survey of the Dabus Valley Controlled Hunting Area, and thereafter contributing resources for the management of this protected area, and others which may be adopted in partnership with responsible government bodies and local communities.

In addition, Mandaya reservoir itself would be a very large wetland resource, supporting fisheries development and being habitat for many local and migratory water birds. With a visitors' centre established by the project, it would become a focal point for studies of natural history for residents of Benishangul Gumuz region and from more distant regions.

No known commercial mineral deposits would be adversely affected by the project. However, any contribution made by the Abbay from upstream of Mandaya to alluvial gold found in the river bed and banks downstream of Mandaya, where gold panning is an important dry season activity, will be permanently curtailed by reservoir impoundment.

E1.4.2 Construction – socio-economic impacts in Ethiopia

Mitigation of the socio-economic impacts of the project in Ethiopia, following detailed assessment of these in future EIA and RAP studies, will require conscientious attention to land and property acquisition (all land is owned by the state), compensation for loss of property, natural resources and livelihoods, and an all embracing resettlement and development program, following national and international safeguard procedures for involuntary resettlement. Both are now well developed and were successfully implemented at Gilgel Gibe in recent years. There is no reason currently to believe that socio-economic mitigation measures in Ethiopia cannot be successfully implemented and sustained following much more detailed assessment and planning.

E1.4.3 Regional impacts in Ethiopia

A new bridge across the Abbay, downstream of the dam site, and some of the project's upgraded and new roads, will make an important contribution to development of the region. Employment, and learning and development of new skills by the construction workforce, will improve the socio-economic conditions of many families, both inside and outside of the project area, and assist those with new skills to find productive employment after project construction. New road communications, water supplies, sanitation, education and health facilities, and energy supplies in the host and resettlement communities, coupled with health awareness, fisheries and other development programs, should improve livelihoods immeasurably and further contribute to regional development.

The contribution of the project to wildlife habitat and wildlife in terms of creation of a new (reservoir) wetland for aquatic life and habitat for resident and migratory water birds, and by assistance in improving management of one or more environmental offsets, as compensation for destruction of habitat, is considered imperfect but a positive feature of the project proposals. Coupled with development of the project itself, the new Abbay bridge and road network, and new schools, opportunities will exist for enhancing the environment further and for enjoyment of it by local adults and children alike and visitors to the area.

E1.4.4 Operational Impacts in lower Abbay Valley

Some of the impacts on the lower reaches of Abbay experienced and mitigated in the construction phase will continue in the operational phase. These mainly result from the change in Abbay river's regime, with greatly reduced flood flows and greatly increased dry season flows (Figure E.2).

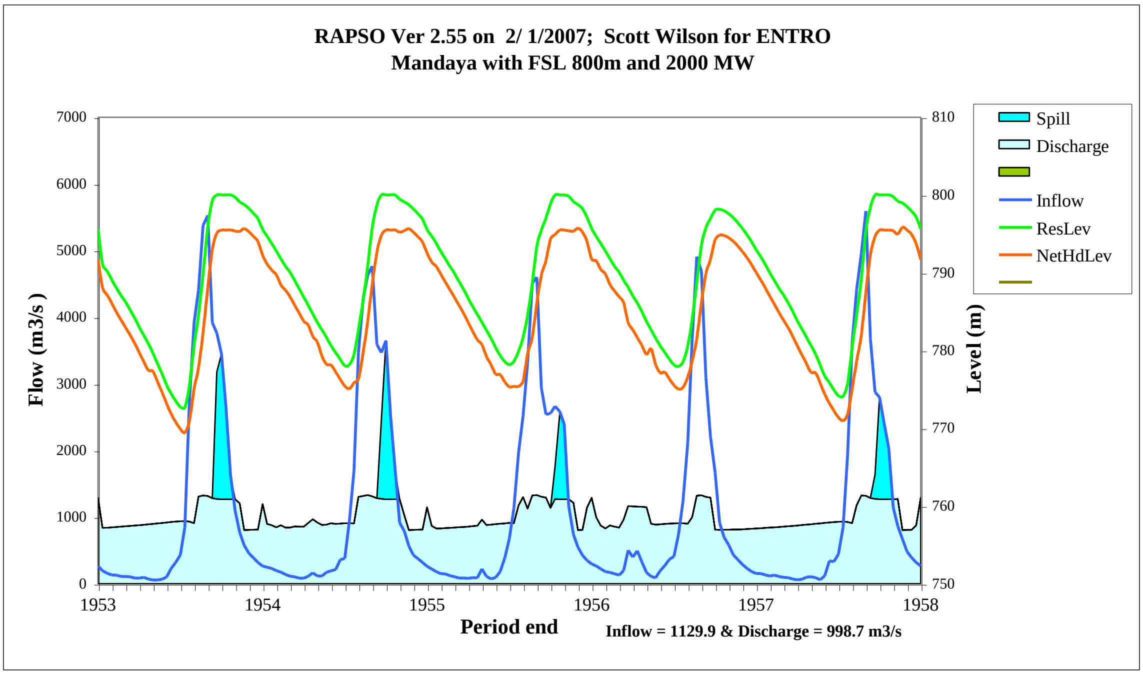


Figure E.2: Mandaya hydropower project simulation, 1954 – 1958

Flow forecasting and warning. Changes in turbined release rates and spillway discharges at Mandaya will require attention to health and safety measures for downstream riparian users through an effective flow forecasting and warning system.

Agriculture. The loss of flood recession agricultural areas, estimated at 2,400 ha, will have been mitigated in the construction phase, either by monetary compensation or by provision of small-scale irrigation facilities. If the earlier mitigation has been to provide small-scale irrigation facilities, these should continue and, if successful, may expand. There will be potential for two crops each year instead of one.

Gold panning. In the operational phase, when dry season flows are significantly raised, opportunities for gold panning in the lower Abbay river channel will probably effectively cease. Compensation will have been provided during the construction phase. Gold panning will be able to continue in Abbay tributaries as before.

E1.4.5 Construction and Operational Impacts in Sudan

Impacts of the Mandaya project in Sudan are expected to be very beneficial for hydropower, irrigation, water supply, fisheries and flood relief.

The holding back of sediment will improve operations and reduce maintenance costs at Roseires, Sennar and Merowe hydropower projects, at gravity fed and pumped irrigation schemes and at water supply offtakes and treatment works. The large augmentation of dry season flows will also benefit Roseires, Sennar and Merowe hydropower projects, irrigation schemes and water supplies. Currently, these facilities suffer from sedimentation and some of them are restricted by availability of flows in the dry season. The raising of dry season flows, and reduction in sediment loads, resulting in new modes of operation in the Sudan hydropower cascade (conjunctive use), will increase energy generation and is expected to improve reservoir fisheries.

It is a remarkable feature that none of the above benefits require explicit or substantial capital expenditure to reap the rewards of river regulation. This is particularly demonstrated by the expected uplift in energy generation at Roseires, Sennar and Merowe (2,211 GWh/year) resulting directly from Mandaya holding back silt and regulating flows, without any capital expenditure at these projects. This uplift in generation is a secondary beneficial impact of the Mandaya project and is greater than the preliminarily estimated energy generation at Low Dal that would involve a substantial capital outlay (project engineering cost USD 1,131 million), loss of productive land, a major resettlement program, a major archaeological survey and salvage program and a large loss of water by evaporation. Dal’s annual evaporation losses, expressed as cubic metres per GWh/year generation are nine times greater than for Mandaya. Thus, the uplift of energy generation in the existing power cascade is not only to be valued in energy terms but may be valued in much wider environmental, social and cultural terms also.

The substantial reduction in sediment transport in the Blue and Main Nile is expected to cause changes in river channel morphology. Some changes may be expected to begin to occur when Mandaya releases its first turbined and spillway discharges (no longer charged with high concentrations of suspended sediment, and with no bed load). Thus the hydraulic conditions will change and the river will have greater energy to entrain alluvial bed and bank materials. Mitigation works in the form of river training and bank protection can be expected. Surveys will be required during future studies in order to estimate the magnitude and extent of changes and to recommend designs of mitigation measures and a management and monitoring plan for these.

The expected impacts on river communications, flood relief and flood recession agriculture are mixed. There are benefits and disadvantages but, as in Egypt 40 years ago, the disadvantages relating to loss of flood recession agriculture can be converted into a reliable and more productive system in the desert.

The raising of dry season flows, and therefore river levels, is expected to benefit navigation (in the form of small fishermen’s boats and ferries) but cause some inconvenience and danger to any pedestrians and livestock crossing of the Blue Nile when flows would normally be very low at the end of dry seasons. This assessment has not been confirmed by field inspection and is speculative. This will need following up in future studies, and linking with impacts of changes in river morphology.

Mandaya's reservoir capacity is very large and simulations of its behaviour over 50 years indicate that spillway flows will account for as little as 5% of all water discharged. A comparison of annual peak discharges (using 10-day records) released from Mandaya with recorded annual maximum daily flood levels has suggested that the degree of flood reduction would be large (Table E.1). This would provide a very significant benefit for flood relief for communities, properties and infrastructure along the Blue and Main Nile downstream, including Khartoum and the Dongola region.

Table E.1 : Indicative Changes in Annual Flood Levels at Khartoum and Dongola

Year	Blue Nile at Khartoum			Main Nile at Dongola		
	Without Mandaya	With Mandaya	With Mandaya	Without Mandaya	With Mandaya	With Mandaya
	Observed Peak Level Gauge height m	Estimated Peak Level Gauge height m	Change in Gauge height m	Observed Peak Level Gauge height m	Estimated Peak Level Gauge height m	Change in Gauge height m
1988	16.94	13.72	-3.22	15.69	14.00	-1.69
1989	16.04	12.50	-3.54	14.15	11.89	-2.26
1990	15.20	11.77	-3.43	13.6	11.39	-2.21
1991	16.14	12.58	-3.56	14.72	12.69	-2.03
1992	16.05	12.72	-3.33	14.64	12.73	-1.91
1993	16.53	13.21	-3.32	14.76	12.79	-1.97
1994	16.94	15.65	-1.29	15.69	15.00	-0.69
1995	15.81	12.93	-2.88	14.74	13.15	-1.59
1996	16.67	14.41	-2.26	15.17	13.90	-1.27
1997	15.97	13.32	-2.65	14.48	12.92	-1.56
1998	17.09	14.90	-2.19	15.91	14.77	-1.14
1999	16.75	14.91	-1.84	15.72	14.76	-0.96
2000	16.60	12.75	-3.85	15.37	13.32	-2.05
2001	16.74	15.05	-1.69	15.93	15.07	-0.86
2002	15.52	12.87	-2.65	14.44	12.95	-1.49
2003	16.38	13.36	-3.02	15.29	13.68	-1.61

Note: the colour coding of flood levels in these 16 years follows the system adopted by the Ministry of Irrigation and Water Resources, Khartoum

Flooding	Critical	Alert	Normal
(red)	(yellow)	(cyan)	(green)

Owing to Mandaya's major impacts on flood levels, recession agriculture along the Blue Nile and Main Nile's alluvial strip will be adversely affected. In all years, the build up of Nile flood levels in June, July and early August will be reduced and delayed as Mandaya reservoir refills; some build up in flood levels will occur as normal because of the tributary rising floods of Dabus, Beles, Dinder, Rahad and Atbara rivers but these are normally small compared to Abbay's contribution.

Because of the reductions in annual flood flows, many floodplain areas will not be reached by flooding, and the depth and duration of flooding will be correspondingly less. Significant reductions in crop production will result and groundwater resources will not be replenished as under normal conditions. These conditions would have knock on impacts for livestock in terms of reduced vegetation for grazing, less crop residues, less dung as manure for subsequent cropping, etc. In harsh desert conditions as exist along the course of the Nile, any reduction in the annual flood (except the extreme floods which cause damage) will be sorely felt. Also, the deposition of silt on farmlands, for millennia regarded as a free and natural fertilizer, will be greatly reduced.

A number of autonomous mitigating factors must be seen against this background. There occur a number of extreme drought years (e.g. 1972, 1984, 1986) when the Nile does not flood out of its banks and recession agriculture is severely reduced or doomed for that year, causing a food shortage crisis[1]. Meanwhile, farmers with pumps continue to cultivate. With Mandaya regulation, and with conjunctive use of Roseires reservoir, regulated flows will be more than sufficient for irrigating the whole of the Nile's alluvial strip throughout the year if required, even in these drought years. Secondly, it is the intention of the Ministry of Irrigation and Water Resources to implement more irrigation schemes in flood recession areas in order to produce crops in the non-flood summer season. This will facilitate two crops per year. Those farmers enjoying irrigation already, and those who will benefit from new schemes (121,000 feddan) already planned, will be immune to reduction in flooding, except for additional pumping costs in the annual flood season. Thirdly, the highest floods which cause damage to properties (and these occurred regularly in the 16 years shown in Table E.1) are a "mixed blessing" for farmers; they provide more water than needed, and their duration may spoil or delay cultivation.

Thus, the proposed mitigation measures for Mandaya's reduction in floods is to introduce pumped irrigation schemes universally and to produce two crops every year, making use of artificial fertilizers where needed. Although the main report has preliminary figures for the riverine areas to be commanded by additional pumping to maintain productivity in the Blue and Main Nile's fertile alluvial strip (434,700 feddan), it was noted that the annual energy required for pumping would amount to about 0.5% of the average annual energy generated at Mandaya, and under 3% of the average annual energy uplift in the Sudan cascade made possible by Mandaya's regulation and storage of silt.

This universal conversion to pumped irrigation would be a big undertaking and will require thorough examination in future studies. The proposed conversion would need to be implemented before Mandaya's first filling.

[1] a "normal" flood condition, coloured green, did not occur in the 16 years of observed floods shown in the table, but Mandaya's regulation converts many "flooding", "critical" and "alert" conditions to "normal".

E1.4.6 Construction and Operational Impacts in Egypt

There are several impact areas of the Mandaya project in Egypt, and some secondary ramifications of these depending on mitigation and enhancement measures taken in Sudan. They relate to the levels and surface area of Lake Nasser/Nubia with regard to the local economy and its development around the lake, reduction in sedimentation and to the yield and operation of High Aswan Dam.

Firstly, the period of first filling of Mandaya reservoir will reduce levels of Lake Nasser/Nubia. The degree to which this will occur is dependent on the hydrological sequence experienced at the time of first filling and the downstream release rates adopted at Mandaya. A fall in level of some 12 m appears probable but clearly the fall may be smaller or greater according to circumstances at the time. Whatever the fall is, it will reduce the lake surface area. Both the fall in level and reduced surface area will affect fisheries, agriculture and navigation to some degree and some physical mitigation and other compensation measures, and provision for contingencies, will be required to offset adverse impacts on production, employment and livelihoods around the lake.

If the Mubarak pumping station and its related major irrigation scheme is operational at the time, the reduced lake levels will cause additional pumping costs for which monetary compensation will be required. There should be no reason for the large irrigated area and its farmers to be adversely affected, only the cost of raising water through the additional lift from the lake to the irrigation canal.

The reduced lake levels in the period of first filling will reduce power generation at Aswan for which compensation will be required.

A limited range of reservoir and river simulations has been carried out. These indicate that Lake Nasser/Nubia will recover after some years. This recovery is in part associated with an important feature. When levels are reduced, and the surface area is smaller, large evaporative losses are reduced.

Throughout the first filling sequences which have been examined, Lake Nasser's regulated outflows downstream are maintained.

The report makes the point that "Mandaya's stored water, being upstream, is not lost to the Nile system but always available for release". This sentence, or one framed like it, may require to be embedded in ENTRO's and everyone's thinking. If the project construction is begun, and a very severely dry hydrological sequence occurs which forces greater downstream releases to occur to satisfy water supply demands in Egypt, first filling will be slower and full generation will be delayed. This is an inescapable reality and risk. This risk will need to be accepted by the project Owner and lending agencies. The downstream releases made from Mandaya during first filling and in the operational period will require thorough study, definition and binding agreement of all parties, with variants of these releases also being agreed to cover extreme circumstances.

In the operational period, Mandaya will again impact on Lake Nasser/Nubia during the occurrence of a prolonged and severe drought. At the beginning of such a sequence, Lake Nasser/Nubia levels will be higher than otherwise because of the beneficial releases from Mandaya's large storage. At the end of the drought, Lake Nasser/Nubia levels will remain lower than otherwise for some time because Mandaya will be refilling.

With regard to sedimentation, the holding of most of Abbay's suspended sediment load and all of its bed load in Mandaya reservoir will cause significant reduction in the siltation rate of Lake Nubia/Nasser. This will extend the life of High Aswan Dam and maintain its yield for irrigation, domestic and public water supply and industry for a much longer period of years (more than a century) than might otherwise be the case. This benefit will be extended as watershed management measures are increasingly implemented in the Abbay basin – supported, it is proposed, by funds from the income stream from Mandaya's energy sales.

There may be secondary impacts on Lake Nasser/Nubia from mitigation and enhancement measures taken in Sudan. These are not yet determined. In particular, the water balance resulting from reduced flooding caused by Mandaya and the conversion of recession agriculture areas to irrigation may impact on the amount of water received at High Aswan Dam. On the one hand, reductions in flooding areas (by flows staying within the Nile channel for longer durations) should reduce evaporation and evapo-transpiration losses. On the other hand, the on-going development of irrigation schemes for the summer season, and the proposed extension of irrigation schemes to make farmers independent of Nile flood recession farming as mitigation for Mandaya, with the potential for two crops per year, may or may not reduce flows reaching High Aswan Dam compared to existing conditions. This is an important area for future study.

All flows and evaporation losses are relevant to the Nile Waters Agreement. Thus, the working up of Mandaya's impacts and mitigation measures on the Nile's water resources at High Aswan Dam requires further studies. In the meantime, this scoping study concludes that large reservoir storage, with low evaporation losses, and major power generation at Mandaya in Ethiopia will be found very attractive and that most impacts down river will be beneficial and most of those that appear adverse can be compensated and converted into benefits.

E1.4.7 Summary of Mandaya's principal impacts

Table E.2 : Summary of principal impacts of Mandaya project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Ethiopia			
Mandaya project	Mandaya power generation, a major national energy benefit and increase in foreign exchange earnings	Involuntary resettlement	Resettlement and development program
Mandaya project	Construction employment, new skills for the future	Loss of wildlife habitat and wildlife	New reservoir wetland and management of environmental offset(s)
Mandaya project	New roads, Abbay bridge, promoting regional development	Loss of natural resources	Development of reservoir fisheries
Mandaya project	Extension of rural electrification	Reservoir sedimentation reducing yield and sales	Implementation of watershed management practices
Sudan			
Regulated flows and reduced sediment	Uplift of energy at Roseires, Sennar and Merowe	River morphology changes	River training works
Regulated flows	Additional irrigation		
Regulated flows and higher dry season river levels	Reduction in energy costs for pumping for irrigation		
Reduced sediment	Reduction in dredging costs at Roseires		
Reduced sediment, e.g. at Rahad and Gezira-Managil	Reduction in irrigation canal and drainage canal desilting maintenance costs		
Reduced sediment	Reduction in water supply treatment costs		
Reduced sediment	Reduction in pump replacement costs		

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Regulated flows and reduced sediment	Incremental fisheries production		
Regulated flows, higher in dry season	Navigation	Higher Blue Nile river levels in dry season	Facilitate river crossings for pedestrians and livestock, or compensation
Reduction in flooding	Reductions in health problems, urban flooding, property flooding, and infrastructure maintenance	Reduction in flooding	Conversion of flood recession agriculture to irrigation, and two crops per year
		Reduction in sediment	Application of artificial fertilizers
Egypt			
Reduced sediment	Extension in life of High Aswan Dam		
Opportunity to operate High Aswan Dam at lower level	Reduction in evaporation losses and conversion to usable water supply yield	Opportunity to operate High Aswan Dam at lower level	Reduction in evaporation losses and conversion to usable water supply yield may more than offset reduction in power generation
Opportunity to avoid/reduce spillage e.g. 1998/99	Increased energy output at Aswan; increased yield downstream	Reduction in Lake Nasser level Less energy at Aswan and Socio-economic (fisheries, agriculture, navigation) around lake	Compensation, or negotiate tariff for importing Mandaya energy to compensate for foregone energy at Aswan Various, to be determined, and/or compensation
Regional			
Mandaya project	Carbon emissions savings of some 424 million tonnes compared with equivalent thermal generation		

E1.5 ALTERNATIVES FOR MANDAYA

There are additional and alternative hydropower sites upstream of Mandaya at Mabil, Beko Abo and Karadobi, and at Border downstream. Mandaya's development could be postponed in favour of one or more of these. In the long term, Mandaya's site is so attractive for hydropower development that it will almost certainly be required in cascade with developments at Border, Beko Abo and Karadobi.

There is scope for adopting alternative full supply and minimum operating levels at the site and these must be considered in more detail in future. The prescribed minimum flows adopted during first filling, and for the operational period, require detailed consideration in future in line with more detailed consideration of downstream water demands in Sudan and Egypt. Other areas where alternatives exist are described in the main report. The single thing for which there is no alternative for the project is implementation of watershed management measures throughout the Abbay basin.

E1.6 PUBLIC CONSULTATIONS

Socio-economic surveys of the dam site and reservoir areas have included consultations with regional government and woreda departments. Focus group discussions with local people and local leaders have been held about the project and its impacts on them and on the region. These are summarised in the main report. In general, these consultations revealed that little was previously known about the project. This was not surprising because the potential Abbay dam sites were identified in the 1960s and there has been no detailed follow up studies of them since their identification until now. Most people were found to be greatly in favour of the project believing the road network would improve for their benefit and that employment and other opportunities for improving livelihoods would arise. Assistance was received from all participants concerning cultural practices and values of natural resources used by them; these are included in the report. Without exception, all believed that institutional strengthening would be essential for government at all levels in the region in order to participate effectively in the many roles which would be expected of them.

Individual but not public consultations have taken place about project impacts and mitigation measures in Sudan and Egypt. Full consultations about these will be required in future.

E1.7 ENVIRONMENTAL MANAGEMENT AND MONITORING

Environmental management of the Mandaya project is concerned with implementation of the measures necessary to minimize or offset adverse impacts and to enhance beneficial impacts. In order to be effective, environmental management must be fully integrated with the overall project management effort at all levels, which itself should be aimed at providing a high level of quality control, leading to a project which has been properly designed, constructed and functions efficiently throughout its life.

The main report presents a draft Environmental Management Plan for the project and introduces the probable overall institutional arrangement for project ownership and management, including execution of the Environmental Management Plan as one component of the project. The report also introduces the requirements and components of a Resettlement Action Plan, associated with a broader development plan, which will be needed for people displaced by the project – mainly in the reservoir and dam works areas but possibly along some lengths of transmission lines. A description of a grievance handling procedure is given.

Because of the wide ranging nature of impacts, it is proposed that the project appoints an independent Panel of Experts for the Environment and Community Protection. This panel would be in addition to an independent Panel of Experts on Dam Safety.

The Mandaya project is a large project requiring a number of mitigation measures which are in themselves very considerable undertakings. Each component will require careful management and a first class public relations and communication system which delivers accurate and updated information to stakeholders as the project is planned, constructed and operated.

Some existing institutions will need greatly strengthening, with the possibility of new departments being created in Sudan.

In Ethiopia, overall management will be carried out by the project Owner, supported by a project Environmental Monitoring Unit and a project Resettlement Management Unit. The principal onus for management of construction impacts will rest with contractors – for roads, dam and associated construction, and transmission lines. Monitoring will be carried out by all of these bodies as well as the Environmental Protection Authority in Benishangul Gumuz and Amhara regions. Staff of the project Owner, Environmental Monitoring Unit and Resettlement Management Unit will be appointed and newly equipped for the job. The contractors will provide staff and equipment according to contract documents.

The two regional Environmental Protection Authorities in Ethiopia will require very substantial strengthening by project funding. Other regional government departments will need assistance also. In principle, any one or all of the 12 government departments listed at Asosa in the main report will require assistance. This project support will also extend to zonal, woreda and kebele levels. Additional support may be required for EEPCO's environmental management team for new transmission lines in Ethiopia, and for NGO's like the Ethiopian Wildlife and Natural History Society in relation to surveys and wildlife management of Mandaya reservoir and environmental offsets (e.g. Dabus Valley). Details can only be made known during further studies.

Support will be required for the Ministry of Water Resources in relation to river gauging at a new station downstream of Mandaya dam site and at an existing gauging station further downstream.

In Sudan, the principal management and monitoring agencies are contractors, NEC, Ministry of Irrigation and Water Resources, Higher Council for Environment and Natural Resources and affected State Councils for Environment and Natural Resources. A very considerable amount of support for these agencies may be expected. Some states do not yet have State Councils for Environment and Natural Resources and, if still not existing, will require establishment. Also, the Sudanese Environmental Conservation Society may be expected to play an important role in mitigation projects (field inspection, review of designs and plans, independent monitoring) and will require assistance.

In Sudan, with regard to river gauging, morphological surveys and river training and conversion of flood recession agriculture to irrigation, assistance will be required for the Ministry of Irrigation and Water Resources. Gauging stations along the Blue and Main Nile will need to monitor flows and sediment transport according to existing requirements and according to any others stated in the environmental management and monitoring plans. Any new or expanded departments in the Ministry, such as for morphology and river training and/or for converting flood recession agriculture to irrigation, will require staffing and appropriate budgets.

In Egypt, support is expected to be necessary for the Ministry of Water Resources and Irrigation, Ministry of Agriculture and Land Reclamation and the Egyptian Environmental Affairs Agency for their extended management and monitoring roles around Lake Nasser. The report identifies some NGOs active in research and development works around the lake which may also be candidates for support. Some support should also be considered for assisting authorities with increasing the frequency with which sedimentation surveys of High Aswan Dam are conducted.

At intervals, independent auditing and monitoring will be required. Targets set in the environmental management and monitoring plans must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to the Owner, the independent Panel of Experts for the Environment and Community Protection, local communities and local administrations, government, NGOs and project financiers.

Failures to achieve targets should result in immediate measures to improve conditions.

E1.8 PROJECT COMPENSATION, MITIGATION, MANAGEMENT AND MONITORING COSTS

In this initial environmental examination of the project, it has been possible to make assessments of the compensation and socio-economic mitigation costs of the Mandaya dam project and transmission lines, and to include some allowances for management and monitoring in Ethiopia.

It has not been possible to estimate the costs and benefits of each and every mitigation and enhancement measure in Sudan and Egypt, nor of the management and monitoring costs. These measures and needs are scoped but insufficiently defined and studied to permit cost estimation, and are beyond the scope of this study. Where some indication of these costs and benefits are available, they are mentioned in the report.

A provisional sum of USD 28.6 million has been included for environmental costs in Ethiopia and a further USD 39.7 million for reservoir basin clearance. Together, these represent some 2.8% of the estimated overall project cost.

E1.9 CONCLUSIONS

Initial environmental examination of the Mandaya project indicates that it has many positive impacts and that its negative impacts are capable of mitigation. Some of the latter, such as resettlement and conversion of recession agriculture to irrigation, provided they are generously supported and follow known safeguard policies, should become worthwhile development projects in their own right.

Engineering parameters are not optimised. During feasibility studies, full EIA and RAP studies are required in Ethiopia. Examination of biodiversity and physical cultural matters in Ethiopia reveals that not enough is known about these to draw firm conclusions. Detailed surveys are required of terrestrial and aquatic ecology. These require a minimum of two years to raise the baseline status to permit more competent environmental assessment. ENTRO's project boat may be used to gain access to sites on the river where systematic transect surveys are required, extending from the river beyond the reservoir margins into buffer zones. Further assessment of archaeology is required, leading to a contingency salvage plan for contractors.

A fundamental and immediate requirement is for the river gauging downstream of the Border dam site to become fully operational and produce up-to-date estimates of sediment transport.

Some of the proposed mitigation measures for the Mandaya project are substantial projects. Progress in EIA procedures over the last 20 years has recognised this in relation to resettlement in particular, and it is now common to conduct comprehensive cultural/agricultural/socio-economic studies of potential resettlement areas and resettlement almost as stand-alone projects. Such studies produce RAP reports which are then integrated into EIA reporting. This procedure is satisfactory.

For the Mandaya project, other important sub-studies are required in Sudan (river morphology, conversion of flood recession agriculture to pumped irrigation, quantifying benefits of regulated flows and reduced sediment loads, examining the water balance of the Nile in relation to reduced flooding and increased irrigation) and in Egypt (exploring by simulation modelling and fieldwork the impacts of first filling and operations on Lake Nasser/Nubia in terms of energy, fisheries, agriculture, navigation, evaporation losses and reduced sedimentation).

As each of these sub-studies and developments will have a significant role in determining the design and the costs and benefits of Mandaya, and ultimately the negotiated ownership and investment of the project, there may be merit in proceeding with some of them, or components of them, in advance of engineering site investigations and feasibility studies. Each of these studies will inform others and assist the engineering design.

Thus the standard procedure for hydropower projects of arranging for all study components to be addressed simultaneously during engineering and EIA studies, over a period of say two years, may be inappropriate in this case of a major project on an international waterway.

It is concluded that wisdom is required in building confidence and trust in all stakeholders, and that various components (e.g. converting annually flooded areas – expected by people for millennia – to pumped irrigation) may need further examination with full public consultations before committing resources to studying all components together. In other words, a phase of research and pre-feasibility studies of mitigation (and enhancement) projects may be required in order to establish more clearly whether the mitigation projects themselves will be culturally acceptable and feasible.

These pre-feasibility studies of mitigation works are likely to identify gaps in data availability which will need addressing before they are studied at feasibility level. For example, irrigation along the Blue and Main Nile, to replace the annual flood, is certain to require topographic mapping at a suitable scale for designing irrigation layouts and such mapping may not be available in many areas. River morphology studies would benefit from a pre-feasibility study before considering the finally proposed regulated hydrology – which can only emerge from a comprehensive series of simulation studies, mainly in relation to Lake Nasser, at a later date.

It is therefore concluded that very serious thought is given to preparing the levels and sequencing of future studies for the Mandaya project.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

The Nile River system is shared by 10 riparian countries: Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda. Under the Nile Basin Initiative, all countries agreed and established a basin-wide framework to fight poverty and promote economic development in the region. Action oriented sub-basin programs (NELSAP, ENSAP) were formulated that are intended to shift focus from planning to action on the ground through investment in development projects. For this purpose, ENCOM was established and Ethiopia, Egypt and Sudan have jointly adopted a strategy to develop, utilize and manage water resources of the Eastern Nile Basin in an integrated, equitable and sustainable manner. In doing so, they are guided by a shared vision "to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources".

Over the past 30 years, various sub-groups of the Nile countries have engaged in cooperative activities. However, the inclusion of all countries in a joint dialogue opens up new opportunities for realizing win-win solutions. It also holds the promise for potential greater regional integration, both economic and political, with benefits far exceeding those derived from the Nile river itself. The NBI comprises a Council of Ministers of Water Affairs of the Nile Basin (Nile-COM), a Technical Advisory Committee (Nile-TAC), and a Secretariat (Nile-SEC) located in Entebbe, Uganda.

It is with this background that ENTRO commissioned pre-feasibility studies of three hydropower projects in connection with development of power trading in the eastern Nile region. By investigating three project candidates (Mandaya and Border in Ethiopia, and Dal in Sudan) in much more detail than in earlier identification studies but without the substantial expenses of detailed feasibility level studies, it is expected that one of these will emerge as a favoured project for much more detailed examination.

This report presents the results of scoping social and environmental issues of the Mandaya project, consistent with pre-feasibility level of engineering studies and the budget. The report is based on investigations carried out by Tropics and Scott Wilson between October 2006 and April 2007.

Mandaya dam site and most of the reservoir basin is located on the Abbay river in Benishangul-Gumuz Region in northwestern Ethiopia, some 20 km downstream of the Abbay's confluence with the Didessa river. A portion of the reservoir basin is in Amhara Region.

1.2 APPROACH AND METHODOLOGY ADOPTED FOR THE STUDY

The approach and methodology for the initial environmental examination study follows the established pattern for hydropower projects, as follows:

- Review of Documents. An extensive review of relevant documents has been undertaken, including environmental protection regulations and guidelines, policy papers, Central Statistical Authority's census reports, Abbay Master

Plan reports and maps, Woody Biomass study reports and maps, Cooperative Regional Assessment (CRA) watershed management reports, Flood Preparedness and Early Warning reports and many other technical publications. Documents and information were collected from ENTRO, federal and regional offices and elsewhere.

- Maps and images. The scale of topographical mapping prepared by the Ethiopian Mapping Authority is at 1:50,000 and available for the whole of the dam site and reservoir area. Photographs from the consultant's aerial survey in October 2006 and satellite images obtained via the Internet have been consulted. For the purpose of assessing land use, vegetation cover, infrastructure and other socio-economic activities in identified areas that would be inundated or otherwise directly impacted, use has been made of the extensive Abbay Master Plan study reports and maps, and those of regional sector offices.

- Aerial Survey. An aerial survey was conducted in October 2006.

- Field survey and public participation. The consulting team conducted its first on-site investigations in December 2006 and followed up with more surveys between January and March 2007. Visits were made to Mandaya dam site and accessible surrounding areas, including the lower Abbay and lower Beles rivers, and the uppermost area of the potential Mandaya reservoir at Nekemte-Bure bridge – the most downstream vehicular crossing point of Abbay river in Ethiopia. Fieldwork included water quality sampling, fish and associated aquatic surveys, terrestrial habitat survey, focal group discussions with local communities and discussions and collection of data from relevant regional government and sector offices and in woredas. Focus group discussions were held with local people and organizations, including farmers, elders, public service workers, teachers, health care workers and other relevant stakeholders. Discussions with representatives of regional administration offices focused on demographic data, land management and agricultural activities, local compensation guidelines, and infrastructure. These investigations and consultations have resulted in first hand knowledge of the existing social and environmental conditions, sufficient for scoping the major issues of the Mandaya project and outlining mitigation measures in Ethiopia.

- Downstream Impacts. Fieldwork was conducted along the lower Abbay river in Ethiopia and the Main Nile in Sudan, principally between Dongola and Dal in November 2006, and for the Dal prefeasibility study in April 2007. The Blue Nile from the Ethiopian/Sudan border to Khartoum was visited at Khartoum only. Downstream impact assessment along the Blue Nile and Main Nile in this report is based on fieldwork in Sudan, discussions held with staff of the Ministry of Irrigation and Water Resources and the Remote Sensing Authority in Khartoum and with staff of the Ministry of Water Resources and Irrigation in Cairo. Downstream impact assessment was supported by examination of satellite images and results of a river and reservoir behaviour simulation model for Mandaya using 50 years river flow data with a 10-day time step, and the results of first filling studies in association with the model's output for Lake Nasser/Nubia.

- Workshops. Preliminary results of scoping investigations at Mandaya (and Border and Dal) were presented at ENTRO workshops in Khartoum in January 2007, at Cairo in March 2007, at Khartoum in June 2007 and at Cairo in July 2007. Formal and informal feedbacks from participants at these meetings assisted the subsequent preparation of this report.

1.3 AREAS OF STUDY

The principal social and environmental impacts of the Mandaya project occur in three principal zones. In addition, a fourth area of interest is relevant.

1.3.1 Direct impact zone

The most direct impacts are associated with land use changes for access roads, the principal construction areas at and near the dam site and for towers along transmission line routes, and for reservoir inundation. The latter involves flooding a very large area, some 736 km^2 for the Full Supply Level of 800 masl adopted in the pre-feasibility engineering study. It is these construction and reservoir impoundment areas, and their regional and woreda administrations, that have been the principal areas of focus for fieldwork and data collection.

1.3.2 Secondary impact zone

Secondary impact areas in Ethiopia extend downstream of Mandaya dam site and construction works area along the Abbay, through the potential Border project site to the Ethiopia/Sudan border. In Sudan, they extend from the Ethiopia/Sudan border along the river channel and related adjacent floodplain and wetland areas of the Blue Nile and Main Nile to Lake Nubia/Nasser. This long river reach would be impacted because of changes in the hydrological regime, principally by reservoir first filling, increases in dry season flows, decreases in flood flows and decreases in sediment transport from Ethiopia to Sudan and to High Aswan Dam. In Egypt, Mandaya's impacts relate principally to Lake Nasser/Nubia with regard to reduced lake levels expected from first filling in the construction period, subsequent periods of low levels in the operational period, and to the reduction in sedimentation in Lake Nasser/Nubia during and following first filling of Mandaya.

1.3.3 International energy benefits

The third principal area of project impacts relates to the national benefits of the new and additional energy supplies that Mandaya project, through interconnection, would bring to the economies of the three countries from its 2,000 MW installed capacity, typically some 12,000 GWh/year. The future demands for additional energy supplies are presented in related power trade reports in this ENTRO assignment. Here, these national and regional energy benefits are taken as being understood from the outset and are not therefore the subject of any original work in this scoping report.

1.3.4 Abbay catchment area

In practice, there is a fourth area of interest which is not directly impacted by the project but which impacts the Mandaya project's medium-term and long-term viability. This is the large Abbay catchment area to Mandaya dam site which yields the water for the project's energy generation and the sediment load. Thus the current and future land use and soil and water conservation activities in the Abbay's catchment area, including additional consumptive use for irrigation schemes and any water transfers from the basin, would impact upon the Mandaya project. A summary of these matters, particularly in the form of maps, is integrated with the description of the existing environment of the direct impact zone (as mentioned in 1.3.1 above).

1.4 CONTENTS AND ORGANIZATION OF THE REPORT

This report of an initial social and environmental assessment of the Mandaya hydropower project follows the report contents suggested in the Terms of Reference and is organized as follows:

- Following the Executive Summary, the background and methodology of the study, and its principal study areas, are presented in Chapter 1.
- Chapter 2 summarizes relevant environmental policy, legal and institutional frameworks in Ethiopia, Sudan and Egypt. It proceeds to introduce the African Development Bank's environmental policy and the World Bank safeguard policies that are considered for the project. It concludes by presenting the provisions of the Nile Waters Treaty (1959).
- Chapter 3 provides a description of the engineering project as studied at pre-feasibility level in parallel with this report.
- Chapter 4 presents the existing environmental and social conditions of the project-affected areas in Ethiopia. For convenience of presentation, the conditions downstream along the relatively short distance to the Sudan border, through the potential Border reservoir area, are described in this chapter.
- Chapter 5 presents the existing environmental and social conditions and key issues along the Blue Nile and Main Nile in Sudan and around Lake Nasser in Egypt. In Chapters 4 and 5, baseline environmental conditions are presented, where usefully separable, in three categories: physical, biological and socio-economic environments.
- Chapter 6 describes the Mandaya project's principal potential impacts and mitigations during construction over a period of ten years. It anticipates management and monitoring plans for these and considers aspects of river diversion and then full reservoir impoundment before presenting principal impacts on the physical, biological and socio-economic environments in the Mandaya region respectively – the direct impact zone. The final section considers construction and impoundment impacts in the downstream area of Ethiopia, and Sudan and Egypt – the secondary impact zone.

- Chapter 7 describes the Mandaya project's principal potential impacts and mitigations during the operation phase, following first filling. It first introduces the principal hydrological impacts of the operation of Mandaya reservoir, and the alteration of downstream flows. These are the fundamental primary operational impacts of the project. The chapter continues with a description of the overall situation expected in the Mandaya area at the beginning of the operations phase before considering principal impacts on the bio-physical and socio-economic environments in the Mandaya region – the direct impact zone. The final sections consider operational impacts and mitigation measures along the lower Abbay river in Ethiopia, and in Sudan and Egypt – the secondary impact zone.
- Chapter 8 considers project alternatives.
- Chapter 9 presents a draft environmental management plan for the project and describes the institutional strengthening which is expected for managing and monitoring the project in the three countries. It then outlines a resettlement action plan and presents a suggested format for handling and resolving grievances.
- Chapter 10 presents a consolidated environmental monitoring plan for the project covering three countries and concludes with indicating some of the principal items to be monitored at resettlement sites.
- Chapter 11 presents an indicative summary of costs of environmental mitigation and enhancement measures, management and monitoring.
- Chapter 12 presents conclusions drawn from screening the project in a global and regional context and lists the conclusions reached about further actions required to move the project forward.

Appendices at the back of the report include:

- Team members of Initial Environmental Assessment studies
- A record of principal consultations
- Baseline data on aquatic ecology
- A summary of ENTRO-boat assisted fieldwork at Mandaya
- Contacted people and organizations
- Participants of Focal Group Discussions
- A nurse's concerns about project development
- Results of analysis of satellite imagery to establish areas of vegetation in the alluvial flood plain of Blue and Main Nile supported by the annual flood
- Flood damage in Sudan
- Mandaya Hydropower project – CO_2 Emissions
- Note on compensation procedures in Sudan and Egypt
- Draft Terms of Reference for full EIA study

2. ENVIRONMENTAL POLICY LEGISLATIVE AND ADMINISTRATIVE FRAMEWORK

This chapter presents relevant environmental policies, legislative and administrative frameworks at regional, national and international level, including summaries of the African Development Bank's environmental policy and the World Bank's safeguard policies that will or may be triggered by the project. Focus has been given to regional level organizations that are responsible for preparation of environmental policy, technical guidelines, review and close follow-up of implementation of environmental safeguard measures.

2.1 ETHIOPIA - NATIONAL POLICY AND STRATEGIES

2.1.1 The Constitution

The Constitution of the Federal Democratic Republic of Ethiopia, which entered into force on August 21st 1995, forms the fundamental basis for enactment of specific legislative instruments governing environmental matters at the national level. Articles 43, 44 and 92 of the Constitution specifically deal with the right to development, environmental rights and environmental objectives respectively. Thus:

In a section that deals with the right to development:

- Article 43 (1) gives broad right to the peoples of Ethiopia to improved living standards and to sustainable development.
- Article 43 (2) acknowledges the rights of the people to be consulted with respect to policies and projects affecting their community.
- Article 43 (3) requires all international agreements and relations by the State to protect and ensure Ethiopia's right to sustainable development.

In a section that deals with environmental rights Article 44 guarantees the right to a clean and healthy environment.

In a section that deals with environmental objectives, Article 92 sets out the Federal policy principles and significant environmental objectives. More specifically Article 92:

- affirms the commitment of the Government to endeavour to ensure that all Ethiopians live in a clean and healthy environment.
- warns that the design and implementation of development programs and projects should not to damage or destroy the environment.
- guarantees the right of people to full consultation and their expression of views in the planning and implementation of environmental policies on projects that affect them directly.
- imposes the duty on Government and citizens to protect the environment.

In the context of land ownership and holding right:

- Article 40 (3) vests the right to ownership of rural and urban land, as well as of all natural resources, in the government and in the peoples of Ethiopia. It recognizes land as a common property of the Nations, Nationalities of and peoples of Ethiopia and prohibits sale or any other exchange of land.

- Article 40 (4) guarantees the right of farmers to obtain land without payment and protection against eviction from their possession.

- Article 40 (5) guarantees the right of pastoralists to free land for grazing and cultivation as well as the right not to be displaced from their own lands.

In recognition of the value of human input on land Article 40 (7) states that "Every Ethiopian shall have the full right to the immovable property he builds and to the permanent improvements he brings about on the land by his labour or capital. This right shall include the right to alienate, to bequeath, and where the right to use expires to remove his property, transfer his title, or claim compensation for it."

In recognition of the right to acquire property for the purpose of overriding national interest Article 40 (7) empowers the Government to expropriate private property for public purposes subject to payment in advance of compensation commensurate to the value of the property."

In a section that deals with economic, social and cultural rights Article 41 (9) sets out the State responsibilities to protect and preserve historical and cultural legacies.

2.1.2 Environmental Policy of Ethiopia

The Environmental Policy of the Federal Democratic Republic of Ethiopia was approved by the Council of Ministers in April 1997. Its overall policy goal may be summarised in terms of the improvement and enhancement of the health and quality of life of all Ethiopians, and the promotion of sustainable social and economic development through the adoption of sound environmental management principles. The policy is integrated with the overall long-term strategy of the country - agricultural led industrialization and other key national policies. It sets out its specific objectives and key guiding principles, contains sectoral and cross-sectoral policies and provisions necessary for the appropriate implementation of the Policy itself.

With respect to environmental impact assessment (EIA) the Policy sets out specific policies, key elements of which may be summarized hereunder:

- The need to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and to integrate public consultation within the EIA procedures.

- Incorporation of impact containment measures into the design process of public and private sector development projects and inclusion into EIA of mitigation measures and accident contingency plans.

- Development of detailed technical sectoral guidelines for EIA and environmental auditing.
- Establishment of an interlinked legal and institutional framework for the EIA process to ensure that development projects are subjected to environmental impact assessment, audit and approval in a coordinated manner.
- Development of EIA and environmental auditing capacity within the Environmental Protection Authority, sectoral ministries and agencies as well as regions.

The Policy has been developed as a national instrument enhancing the objectives of the Constitution and setting out clear cut directions with respect to environmental concerns particularly in terms of regulatory measures adopted as well as in the process of design, implementation and operation of development projects. Its recognition of the significance of addressing cross-sectoral environmental issues in the context of a national approach to environmental assessment and management integrates the efforts of a wide range of institutions across the country. It provides a sound and rational basis for addressing the country's environmental problems in a coordinated manner.

2.1.3 Sectoral Policies

As measures to effectively deal with environmental problems several sectoral policies have been issued. These include:

- National Population Policy issued in April 1993
- National Policy on Women issued in March 1993
- National Agricultural Resource Policy and Strategy issued in 1993
- Energy Policy issued in 1994
- Water Resource Management Policy in 1999
- Policy on Biodiversity Conservation and Research issued in April 1998
- Rural Development Policy and Strategy issued in 2002
- Sustainable Development and Poverty Reduction program issued in 2002

The broad guiding principles under the Federal Constitution and the more instructive directions set out under the Environmental Policy of Ethiopia have been further expanded and refined by three environmental framework legislations designed to enable implementation of the Federal policies on environment. These legislations are instrumental to translating the broad objectives of the policies into practice, as they provide for specific rules of substance and procedures having the force of law across the country. The legislations are described below.

2.1.4 National and Regional Conservation Strategies

Ethiopia has formulated a National Conservation Strategy which takes a holistic view of the natural, cultural and human resources and seeks to integrate into a coherent framework, plans, policies and investment related to environmental sustainability. Within this framework, region-specific conservation strategies have been formulated and these have been taken into consideration for this ESIA where these are available. For example, the Amhara Region has in place its own Regional Conservation Strategy (Amhara National Regional State, 1999) but Benishangul Gumuz has not yet produced a strategy for its region.

2.2 ETHIOPIA - LEGAL FRAMEWORK

2.2.1 Legislation on Expropriation of Land and Compensation

The Federal legislation on Expropriation of Land for Public Purposes & Compensation (Proclamation No. 455/2005) in effect repealed the outdated provisions of the Ethiopian Civil Code of 1960 regulating land acquisition and compensation for the purpose of public projects. This new legislation established detail procedures setting the time limits within which land could be acquired after a request is received from a proponent, principles for assessment of compensation for properties on the land as well as for displacement compensation. It also empowered the Woreda administration to establish valuation committees to value private properties. In the case of public-owned infrastructures to be removed from the right-of-way the owners of the structures would assess the value of the properties to be removed. Additionally the legislation provided for appeals on valuation decisions but such action would not delay transfer of possession of land to the proponent or contractor appointed by the proponent.

The Proclamation has removed the barriers for planned land acquisition, substantially raised the amount of compensation payable to expropriated owners of properties and displaced people. In addition to financial compensation in an amount sufficient to reinstate the displaced people to the economic position prior to displacement, the relevant Regional administration is required to give replacement land to any person who has lost land in favour of a public project. An assessment of compensation does not include the value of the land itself since land is a public property not subject to sale in Ethiopia.

The responsibility of a proponent of a proposed project under Ethiopian law does not extend beyond the payment of compensation for properties and displacement. In other words the displaced people need to seek resettlement options in the framework of land administration systems of the relevant rural or urban land administration.

2.2.2 Legislation on Preservation of Cultural Heritage

The Research and Conservation of Cultural Heritage Proclamation No. 209/2000 of Ethiopia defines cultural heritage broadly as “anything tangible or intangible which is the product of creativity and labour of man in the pre-history and history times, that describes and witnesses to the evolution of nature and which has a major value in its scientific, historical, cultural, artistic and handcraft content.”

Prior approval of the Authority for Research and Conservation of Cultural Heritage is required to remove from its original site, an immovable cultural heritage (Art. 21/1). Whenever a registered movable cultural heritage is encountered during the execution of the project it is possible to remove such property by notifying the Authority in advance (Art. 21/2).

Any person who destroys or damages cultural heritage intentionally shall be punished with gregarious imprisonment not less than 10 years and not exceeding 20 years (Art. 45/2/).

2.2.3 The National Proclamation on Water Resource Management

The Water Resources Management and Administration in the country should be based on the Ethiopian Water Resource Management Policy, and the Water Resources Laws of the country as indicated in Proclamation No 197/2000. The Ministry of Water Resources is entrusted with broad powers of 'planning, management, utilization administration and protection of water resources'. This includes promoting the implementation of medium and large multipurpose dam projects.

According to the Proc. No.197/2000, the duties of the MoWR's are inventory of water resources, allocation of water resources, establishing standards for design and construction of waterworks (including hydropower dams), issuing guidelines and directives for the prevention of pollution of water resources as well as for water quality and health standards, establishing water users' associations, and settlement of disputes.

2.2.4 Environmental Impact Assessment Proclamation

This Proclamation (No 299/2002) aims primarily at making environmental impact assessment (EIA) mandatory for categories of projects specified under a directive issued by the Environmental Protection Authority (see 3.3.1) whether such projects belong to public or private bodies. The Authority issued several directives subjecting categories of projects to environmental impact assessment. The Proclamation describes a policy, strategy, program, law or an international agreement as “public instrument” and directs the Authority to issue guidelines distinctively classifying certain categories of public instruments as likely to entail significant environmental impact. The Proclamation requires, among others:

- Specified categories of projects to be subjected to EIA and receive an authorization from the Authority or the relevant regional environmental agency prior to commencing implementation of the project.
- Licensing agencies to ensure that the requisite authorization has been duly received prior to issuing an investment permit, a trade or operating license or a work permit to a business organization.
- The Authority or the relevant Regional environmental agencies may exempt from environmental impact assessment projects with insignificant environmental impact.

- A licensing agency may suspend or cancel a licence that has already been issued where the Authority or the relevant regional environmental agency suspends or cancels environmental authorization.

Procedures that need to be followed in the process of environmental impact assessment are described in the Proclamation. Thus a project initiator (Proponent):

- Must undertake a timely environmental impact assessment, identifying the likely adverse impacts, incorporate the means of their prevention, and submit the environmental impact study report accompanied by the necessary documents to the Authority or the relevant regional environmental agency.
- Must ensure that an environmental impact assessment is conducted and an environmental impact study report prepared by an expert who meets the requirements set forth by the directive issued by the Authority.
- Must submit an environmental impact study report to the Authority or the relevant Regional environmental agency for review.

The Proclamation directs the Authority and the relevant Regional environmental agency how to deal with an environmental impact study report they receive. Thus, after evaluating the report by taking into account any public comment and expert opinion the Authority or the relevant Regional environmental agency must do one of the following:

- Approve the project without condition and issue authorization if it is satisfied that the project may not cause negative impact.
- Approve the project and issue authorization with condition that must be met in order to reduce adverse impacts to insignificant impacts, or
- Refuse implementation of the project if the negative impact cannot be satisfactorily avoided.

In the event of a project having likely trans-national impact within Ethiopia the regional environmental agency would not assess an environmental impact study itself, but refer the report to the National Authority. The Proclamation has no provision regulating environmental impact assessment of projects crossing the borders of Ethiopia.

2.2.5 Environmental Pollution Control Proclamation

This Proclamation primarily aims to ensure the right of citizens to a healthy environment and to impose obligations to protect the environment of the country. In this connection the Proclamation provides a basis from which the relevant environmental standards applicable to Ethiopia can be developed and sanctions violation of these standards as criminally punishable offences.

In order to ensure implementation of environmental standards and related requirements, inspectors of the Authority or of the relevant Regional environmental agency are empowered by the Proclamation to enter, without prior notice or court order, any land or premises at any time, which seems to them appropriate. Such a wide discretionary power of inspectors explains the serious concern and commitment of Ethiopia to the protection of the environment from pollution.

2.2.6 Institutional Arrangement for Environmental Protection

Of paramount significance in terms of institutional framework for environmental protection is the Environmental Protection Organs Establishment Proclamation No. 295/2002, which entered into force on October 31st 2002. This Proclamation establishes the institutional arms of the Federal Government to ensure the realisation of the objectives of the Constitution and of the Environmental Policy of Ethiopia with respect to environmentally sustainable management of economic and social development of the country, both at Federal and Regional level.

The Proclamation directs every relevant sectoral agency of the Federal Government to set up an environment unit as part of its organizational structure and also for each Regional State to establish a Regional autonomous environmental agency. Apart from assigning specifically defined responsibilities to the Environmental Protection Authority the Proclamation links the efforts of Regional states with that of the Authority by instructing the Regional states to prepare and submit reports on the respective state of the environment and sustainable development and submit them to the Authority.

The significance attached to the Authority is reflected in its composition which is made up of a Council comprising members drawn from the Prime Ministry, Federal Government, Regional States, Ethiopian Chamber of Commerce, Confederation of Trade Unions and local NGOs involved in environmental protection and the Director General of the Authority. The Council is entrusted with the responsibilities of reviewing environmental policies, strategies, laws, providing advice on the implementation of environmental policies, and evaluating the guidelines and environmental standards prepared by the Authority. This guarantees that the Council has approved all guidelines and environmental standards issued by the Authority.

2.2.7 International Agreements

Ethiopia has ratified the following international conventions and protocols pertaining to the environment and which are of relevance to the Project:

- United Nations Framework Convention on Climate Change, 1992
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted on 22 March 1989
- Bamako Convention on the Ban of the Import Into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa, adopted 30 January 1991
- Convention on Biological Diversity, 5 June 1992
- United Nations Convention to Combat Desertification (UNCCD), adopted 1997

- Convention on the Protection of World Cultural and Natural Heritage, ratified 1997.
- Convention on the Means of Prohibiting and Preventing the Elicit, Import, Export and Transfer of Ownership of Cultural property, ratified 2003.

2.3 ETHIOPIA - INSTITUTIONAL ARRANGEMENT AND RELEVANT GUIDELINES

The institutions responsible to ensure implementation of environmental public instruments at Federal and Regional levels are key role players whilst sectoral institutions engaged in development activities reinforce the efforts of the key institutions as partners to the key institution. The key institutions devote their time fully to environmental matters, as they were established for that purpose while sectoral institutions were established for other purposes with limited environmental responsibilities. The latter enhance the objectives of environmental institutions by complying with the environmental objectives of the country in the course of preparing and implementing their own projects.

2.3.1 Ethiopian Environmental Protection Authority

The key institution at Federal level is the Ethiopian Environmental Protection Authority (EPA), which was established on October 31 2002 by Proclamation No. 295/2002. It is the Federal institutional arm entrusted with the widest responsibilities on environmental protection. The Authority reports directly to the Prime Minister and is responsible for:

- Preparation of environmental policies and laws and to ensure that these are implemented.
- Preparation of directives and implementation of systems necessary for the evaluation of the impact of projects on the environment.
- Preparation of environmental protection standards and implementation of directives concerning soil, water and air.
- Preparation of recommendations regarding measures needed to protect the environment.
- Enhancement of environmental awareness programs.
- The conduct of studies on desertification and the coordination of efforts to combat it.
- Implementation of international treaties concerning the environment to which Ethiopia is a signatory.
- Provision of advice and technical support to the regions on environmental matters.

The Proclamation gives the EPA a mandate to involve itself with all environmental issues and projects that have a Federal, interregional and international scope. Most of the powers of the EPA relate to coordination and monitoring aspects.

2.3.2 Regional Environmental Agencies

Proclamation No. 295/2002 empowers each Regional state to establish its own independent environmental agency with the responsibilities to coordinate and follow-up the Regional effort to ensure public participation in the decision making process, to play an active role in coordinating the formulation, implementation, review and revision of Regional conservation strategies as well as to foster environmental monitoring, protection and regulation.

2.3.3 Sectoral Environmental Units

Each Federal and Regional organization of the government that deals with environmental matters is required by Proclamation No. 295/2002 to set up its own unit with the responsibilities to coordinate and follow-up in order to ensure that its activities are in harmony with national efforts to protect the environment. Several institutions at regional and federal level have established their in-house environmental unit.

2.3.4 Environmental Guidelines

As a step forward in developing the environmental policies and legislations the Environmental Protection Authority issued a procedural guideline which defines specific examinations to which a proposed project needs to be subjected in the process of environmental impact assessment. The procedural guideline currently in effect is one that was issued in November 2003 and sets forth the various stages of evaluation that a project proposal needs to pass through. These stages are pre-screening consultation, screening, scoping, environmental impact study, reviewing and decision-making. Pre-screening consultation is not an actual stage in the EA process but a point where the proponent and the relevant environmental organ establish contact and hold consultation on how best to proceed with the EA. The environmental organ may also conduct environmental audit or surveillance of a project to ensure compliance with the environmental quality criteria or other provisions stated in the environmental impact assessment.

The procedural guideline requires a proponent to submit an initial environmental examination report to enable the relevant environmental agency to decide the application of a further level of assessment depending on the outcome of a screening report. At this level of examination the decision may be either of the following: no EA required, preliminary assessment is applied to or full scale EA applies where the project is found to be one that may have significant impacts.

The Ethiopian Environmental Protection Authority has issued other guidelines for environmental and social impact assessment of projects in different sectors. These include:

- Guidelines for Dams and Reservoirs, 2004

- Guidelines on Irrigation, 2004
- Guidelines for Mineral and Petroleum Operation Projects, 2003
- Guidelines on Road and Railway, 2004
- Guidelines on Hydropower Production, Transportation and Distribution
- Guideline on ambient water quality of domestic, agricultural and industrial wastes

These guidelines provide a comprehensive statement of the type of adverse impact that may occur and set out clearly the aspects, which need to be addressed in an initial environmental examination and in an environmental and social impact assessment. The guidelines are clear and understandable in their application, and more importantly provide a sound basis for examination and assessment of projects in the sectors for which they were designed. The source of references and further reading accompanying each guideline point out the extent of professional research conducted to develop the guidelines and encourages further reading in selected areas covered by the guidelines.

2.4 SUDAN – NATIONAL POLICY AND STRATEGY

In the Sudan federal system there are three levels of authority: national level, state level and locality level. The powers over land and other natural resources are divided among the various levels as follows:

- At the national level, the federal organs exercise the power of planning, legislation and execution on federal lands, natural resources, mineral and subterranean wealth, inter – state waters, national electricity projects, epidemics and disasters.
- The state organs within the boundaries of the state exercise power on state lands, natural resources, animal resources, wildlife, non-Nile waters and electric power.
- There are concurrent powers where both federal (national) and state organs exercise power on education, health, environment, tourism, industry and meteorology.

This section presents relevant environmental policies, legislative and administrative frameworks at state, federal and international level. Focus has been given to state level organizations that are responsible for preparation of environmental policy, technical guidelines, review and follow-up of implementation of environmental safeguard measures.

2.4.1 National Policy and Strategies

The 2005 Interim National Constitution (INC) of the Republic of the Sudan, which came shortly after the signing of the Comprehensive Peace Agreement (CPA) between the ruling National Congress Party (NCP) and the Sudan People's

Liberation Movement (SPLM), was the first in the history of Sudan to formally recognise the subject of “Environmental Pollution and Ecology” and placed the subject on the Concurrent Legislative List. Environment and social justice enjoy the protection of the INC wherein Chapter II: Guiding Principles and Directives, Section 11 on Environment and Natural Resources:

- guarantees the right of the Sudanese’s people to clean and diverse environment while imposing a duty on the citizens to preserve and promote the country’s biodiversity;

- precludes the State from pursuing any policy, or taking or permitting any action, which may adversely affect the existence of any special animals or vegetative life or their natural or adopted habitat; and

- guarantees that the State shall promote, through legislation, sustainable utilisation of natural resources and best practices with respect to their management.

The Interim Constitution provides for the creation of commissions, particularly on land to assume among others planning and division of lands and forests between federal and state authorities. Section 12 requires the State:

- to develop policies and strategies to ensure social justice through ensuring means of livelihood and opportunities of employment.

- to encourage mutual assistance, self-help, cooperation and charity.

Section 24 describes the Sudan as the decentralised State with three levels of government:

1. the national level of government with the power to protect national sovereignty, and territorial integrity of the entire Sudan and to promote the welfare of its people,

2. the State level of government with the power to exercise authority at the State level throughout the Sudan, and render public services through the level closest to the people, and

3. the local level of government, which shall be throughout the Sudan.

The Interim Constitution has five Schedules (Schedules A-F), which more specifically state the powers of the various level of government in respect of, among others, environment, land acquisition and conservation of cultural heritage. Such powers include:

1) Exclusive legislative and executive powers of the national level as stated under Schedule A:

- Natural lands and national natural resources (item no. 15),
- Meteorology (item no. 19),

- Signing of International Treaties on behalf of the Republic of Sudan (item no. 25),
- National Public Utilities (item no. 30),
- National Museums and National heritage Sites (item no. 31),
- National Economic Policy and Planning (item no. 32), and
- Nile Water Commission, the management of the Nile Waters and transboundary waters and disputes arising from the management of interstate waters (item no. 31).

2) Exclusive legislative and executive powers of a State of the Sudan as stated under Schedule C:

- State Land and State Natural Resources (item no. 8),
- Cultural matters within the state (item no. 9),
- Enforcement of state laws (item no. 19),
- The development, conservation and management of state natural resources and state forestry resources (item no. 21),
- Laws relating to Agriculture within the state (item no. 23),
- Pollution control (item no. 27),
- Quarrying regulations (item no. 31),
- Town and rural planning (item no. 32),
- State cultural and heritage sites… and other historical sites (item no. 33),
- Traditional and customary law (item no. 34),
- State irrigation and embankments (item no. 36),
- State archives, antiquities and monuments (item no. 38), and
- State public utilities (item no. 40).

Schedule E provides for residual powers exercised by the relevant level of government depending on the nature to which they relate. Schedule F deals with the resolution of disputes in relation to concurrent powers at various levels of government. New legislations expounding the broad principles of the Interim Constitution may be enacted while revision or repeal of some of the existing laws might be considered in order to conform to the provisions of the Constitution.

Article 43 (2) of the Interim Constitution gives the federal government the right to expropriate land for development purposes and to compensate owners. There are a number of articles related to natural resource management, protection of cultural heritage sites and respect of traditional and customary regulations related to land ownership.

The Interim Constitution also specifies land issues which are under national powers (federal level) and those under the control of states as well as joint powers (concurrent powers) shared by federal and states. The States manage issues related to State lands which are not under national control. These include: management, lease and utilization of lands belonging to States, town and rural planning and agricultural lands within the State boundaries. The concurrent powers include matters related to urban development, planning and housing, electricity generation, waste management, consumer safety and protection, water resources other than inter-state waters and regulation of land tenure and the rights on land.

2.5 SUDAN - LEGAL FRAMEWORK

Environment as a direct concern of the Government of Sudan dates back to the British colonial government. Until that time, environmental protection was the concern of weakly enforced indirect provisions in local, provincial, and federal laws. These provisions were mainly designed to improve civic and factory conditions and the management of canals, forests, and wildlife.

The national legal framework for protection of the environment in Sudan is acknowledged by all concerned to be weak. A study carried out with the help of UNEP in 1994 discovered over 120 references to environmental legislation over a wide range of topics (e.g. soils, pesticides, wildlife, etc.) and with authority spread among over 30 government bodies. Furthermore, there was no national coordination of environmental policy.

In an effort to remedy this situation, particularly in the light of obligations taken at the1992 Rio Conference, the Higher Council of Environment and Natural Resources (HCENR) has taken the lead in drafting a new framework law for the environment. This is an “umbrella” law that clarifies the role of the Ministry of Environment and Physical Development as the competent Ministry responsible for coordinating all matters concerning the environment. However, the new law also acknowledges that other Government Ministries with particular competence in certain fields are responsible for developing environmental measures within their areas of competence, e.g. the Ministry of Transport as the appropriate Ministry to implement measures to prevent pollution from ships.

In 2000 the federal cabinet directed the drafting of “an overall legislation for environmental protection”. In the same year, the Ministry of Environment and Physical Planning was established. The role of the Ministry or the concept of environment however, continued to be restricted to the living conditions and planning and housing sector. The most notable achievement in the 2001 was the enactment of the Sudan Environmental Protection Act (EPA). The EPA envisaged the HCENR as a policy making body and the environmental protection agency for implementation of the Ordinance. Although without executive powers and scantily staffed, the HCENR enjoyed considerable international exposure. The HCENR met irregularly, the establishment of state environment and natural resources councils was very slow, federal and state environmental conservation strategies and standards are yet to be developed.

Currently, Sudan has drafted a National Environmental Action Plan (NEAP) comprising strategies for management of natural resources and the environment.

2.5.1 Environment Related Laws in Sudan

The Sudan Environmental Protection Act, 2001 is the basic environmental law in Sudan. The act is first in the history of Sudan and meant to overcome the deficiencies in existing laws, which were considered narrow in scope, conflicting and fragmentary. Various regulations relating to the environment have been promulgated since the colonial time and to date some are still under review. Various other laws cover different facets of environmental protection, biodiversity, cultural heritage, and natural resources.

a. Environmental Protection Act of 2001

The Environmental Protection Act of 2001 provides an umbrella law and general principles to be considered in carrying out EIA studies. This law provides definitions and several clarifications regarding natural resources management, sources of pollution and pollutants and endorses the principal of the "polluter pays". The act also make it the responsibility of the project proponents, before embarking on any development activity, to carryout an EIA study, to identify the positive and negative environmental impacts with suggestions to mitigate adverse impacts According to the Act, such studies must contain the following:

- Description of the existing environmental conditions as a baseline.
- Description of the project.
- Assessment of potential environmental impacts, both positive and negative throughout the project phases.
- Provision of recommendations to mitigate the negative environmental effects.

According to this Act all development projects outside environmentally protected areas and in environmentally sensitive areas require an EIA. Proponents of all projects are required to monitor their projects and submit reports to the HCENR.

b. Environmental Health Act 1975, the Public Health Act 1975

These Acts ensure the correct calculation, reporting and payment of pollution charges by polluting/industrial units. They require the owners, tenants or occupiers of commercial and industrial concerns to have at their own cost prepared and implement a scheme for the safe drainage and disposal of their wastes and effluents of the quality permitted under the rules or the bye-laws. Pollution units per unit of production are the basis for calculation of the pollution charge by the industrial unit.

c. Industrial Relations Act 1976, Minimum Wage Act 1974

These acts deal with employment terms and conditions including such issues as minimum wage, health insurance and redundancy payment.

d. Electricity Act 2001

The Act of 2001 relates to the generation, transmission, supply, and use of electricity in the Sudan.

e. Weapons, Ammunition and Explosive Act 1986 (WAEA)

The WAEA 1986 gives the central government the power to make rules as to licensing of the manufacture, possession, use, sale, transport and importation of explosives. The Act also gives the authority to grant licenses, the fees to be charged for licenses, and the other sums (if any) to be paid for expenses by applicants for licenses; the manner in which application for licenses must be and the matters to be specified in such applications; the form in which, and the conditions on and subject to which, licenses must be granted; and the period for which licenses are to remain in force

f. Land Acquisition Ordinance 1930

This act is the legal umbrella under which the government or private parties, subject to certain conditions and procedures, may in the interest of the public undertake compulsory acquisition of land. The land may be acquired for use in development activities or projects, which directly or indirectly promote the general welfare of the public.

g. Unregistered Land Act 1970

The 1970 Unregistered Land Act declared all unregistered land as government land. The declaration was made without recognition of the long established and existing usufruct rights communally enjoyed village or pastoral communities. The Act is an amendment to the Land Settlement and Registration Ordinance 1925, which recognized usufruct customary rights with respect to unregistered land.

h. Wildlife Protection and National Parks Act 1986

This Act was issued to provide protection, preservation, conservation and management of wildlife and setting up of a National Park. This Act is applicable to all areas for protection, conservation and preservation and management of wildlife.

i. Forestry Act 1989, Forests and Renewable Natural Resources Act 2002

These Acts empower provincial governments to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce; quarrying and felling, lopping and topping of trees, branches in reserved or protected areas. Penalties for breach of regulation and payment of cash compensation are provided in these Acts.

2.5.2 Legislation on Land Acquisition and Compensation

Specific details and procedures on land are found in sectoral laws including:

- Land Settlement and Registration Ordinance 1925 provides rules to determine rights on land and other rights attached to it and ensure land registration.

- Land Acquisition Act 1930 gives the government the power to appropriate lands for development purposes. It also states detail formalities of acquisition and rules governing assessment and payment of compensation. The Act outlines detailed procedures to be followed in the acquisition of land and rules governing payment of compensation for land for public purposes. The procedures for land acquisition in any locality are initiated with a notification by the People’s Executive Council in a Gazette stating that it appeared to the President of the Republic to authorize the acquisition of land for public purposes (Section 4). It is only after such notification that it shall be lawful to enter into, bore, set out boundaries, mark or survey the land. An appropriation officer appointed by the People’s Executive Council would notify the occupant of land the declaration that a designated area of land is to be appropriated for public purposes; call upon persons claiming compensation to appear before him at a place and time (not earlier than fourteen days) and to state the particulars of their claims for compensation (Section 10). He must attempt to agree on the amount of compensation for the land. The Act provides for further steps to be taken with regard to assessment of compensation if agreement is not reached.

- Unregistered Land Act 1970 deems any unregistered land, before the enactment of this law, as being registered in the name of the government.

- The Civil Transactions Act 1984 regulates the different matters related to civil transactions with respect to titles on land, means of land acquisition, easement rights and conditions to be observed by land users.

- Urban Planning and Land Disposal Act 1994 regulates designation of lands for different purposes and urban planning. With respect to land expropriation for public purposes Section13 of the Act recognizes the application of its predecessor – Land Acquisition Act, 1930

- Central Forest Act, 1932 empowers the Minister of Agriculture, Food and Natural Resources to declare to be a central forest reserve an area of land, which is registered under the Land and Settlement and Registration Act, 1925 as a Government land (Section 5). Unless with special license or a permit has been first obtained from the Director of Forest any act, including entry upon or remaining in such forests would be an offence (Sections 9 & 10 of Central Forest Act, 1932).

- Provincial Forest Act, 1932 protects an area in Gezira province as provincial forest reserve from being interfered with on the same principle as applied to the central forest reserve.

- The Environmental Health Act, 1975 contains detailed provisions for the protection of water and air from pollution and assigns defined administrative responsibilities to District Councils with respect to preservation of environmental health in general.

Generally, these Acts provide procedures for land expropriation for development purposes and ways to specify rights in order to compensate the owner. The Urban Planning Act sets specific rules for the separation of industrial areas from residential areas.

2.5.3 Legislation on Preservation of Cultural Heritage

The Antiquities Ordinance of 1905, 1952 and the Antiquities Protection Act 1999 are the principal national legislations that deal with the protection and preservation of Sudan’s archaeological heritage. These acts empower the Government to preserve and protect any premises or objects of archaeological, architectural, historical, cultural, or national interest in Sudan by declaring them protected; compulsorily purchasing them; or making arrangements to restore and maintain the object or premises.

2.6 SUDAN - INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL PROTECTION

2.6.1 Higher Council for Environment and Natural Resources

The Higher Council for Environment and Natural Resources was founded in 1992, as part of the Sudan's follow-up to the Rio Conference, with the task of coordinating national plans and policies on the environment. Headed by a federal minister, the Ministry of Environment and Physical Development is the main government organization responsible for the protection of environment and resource conservation. The Ministry works with the Higher Council for Environment and Natural Resources (HCENR). The HCENR is a high-level committee comprising the Minister of Environment and Physical Development as the Chairperson; the Khartoum State Governor; federal ministers; environmentalists and community representatives. The functions of the Council include policy formulation and approval of standards. The state governors chair the SCENR.

The HCENR's objectives are the sustainable utilisation, rational development and conservation of natural resources, undertaken through line Ministries and public bodies. Apart from steering through the new environment law, the HCENR has coordinated major projects on Strategic Planning (funded by UNDP, 1996-1999), on Climate Change (funded by GEF, 1998-2001) and on a Biodiversity Action Plan (funded by GEF, 1999-2003).

2.6.2 State Council for Environment and Natural Resources

The Environmental Protection Act 2001 empowers each state to establish its own independent State Council for Environment and Natural Resources (SCENR) with the responsibilities to coordinate and follow-up the state effort to ensure public participation in the decision making process, to play an active role in coordinating the formulation and implementation of conservation policies as well as to foster environmental monitoring, protection and regulation.

However, like most other states in Sudan, the Northern State is yet to promulgate an act for the establishment of the State Council Environment and Natural Resources (SCENR)

2.6.3 Wildlife Conservation General Administration

The Wildlife Conservation General Administration (WCGA) is responsible for formulation of national wildlife policies; co-ordination with provincial wildlife departments on the implementation of these policies; and co-ordination with international organisations on matters related to international treaties. The WCGA works under the Ministry of Interior.

2.6.4 Antiquities and Museums National Corporation

The Antiquities and Museums National Corporation (AMNC) under the Federal Ministry of Culture is the custodian of the nation's cultural heritage. The main functions of the Department are as follows:

- Preservation and conservation of historical and archaeological monuments
- Exploration and excavation
- Collaboration with foreign archaeological missions working at various sites in Sudan
- Control of movement of cultural property
- Establishment and maintenance of museums
- Treatment and restoration of antiquities
- Administration of the Antiquities and Museums National Corporation Act, 1991
- Research on epigraphy, numismatics, and other relevant fields of archaeology
- Organisation of seminars, symposia, and workshops at the national and international level

The State governments have not yet enacted laws governing archaeological and historical sites.

2.6.5 Dams Implementation Unit

The Dams Implementation Unit (DIU) is an upgrading of the Merowe Dam Project Implementation Unit (MDPIU), which was headed by the State Minister for Irrigation and Water Resources. DIU is an autonomous body directly under the Office of the President of the Republic with a status of full Federal Ministry. The responsibility for the formulation and execution of resettlement and compensation policies is assigned to the Commission for Environmental and Social Affairs of the DIU.

2.6.6 Other Government Institutions

Other government institutions with designated responsibility for natural resource management are sectorally organised, in line with the general arrangements for administration and development between the federal, state and local governments.

2.6.7 Civil Society

Numerous national and local NGOs are active in the social sector in the Northern State: emergency support, rehabilitation, health, and education. Other areas include environmental conservation, income generation, poverty reduction, vocational training, nutrition and food security, and maternal, child health and family planning. The most important NGO in the Northern State is the Sudanese Red Crescent working in disaster (mainly flood) management.

The Sudanese Environment Conservation Society (SECS) is the most popular in terms of its composition and size of membership, regional coverage, and the range of environmental issues tackled. However, in the Northern State SECS branches are among the most inactive in the country.

2.7 SUDAN - INTERNATIONAL CONVENTIONS

Sudan is a signatory to a number of international and regional treaties addressing environmental conservation. The implications of these treaties for the hydropower projects are discussed below. Global and regional treaties are, in principle, binding in the first instance on national governments, which are obliged to implement such arrangements through national legislation. In the Sudan speed and timing of implementation of international have been slow and not all international treaties have a local legislation to support their implementation. However, it is prudent and environmentally desirable for the proponents of hydropower projects to ensure that the intent of such treaties is respected. A summary of the international conventions is provided below.

2.7.1 The Convention on Conservation of Migratory Species of Wild Animals, 1979

The Convention requires countries to take action to avoid endangering migratory species. Species covered in the Convention should be given special attention during EIA and monitoring of hydropower projects, and any impacts identified should be mitigated to acceptable levels.

Mitigation measures should be allowed in projects to ensure that for all species in Appendix I of the Convention their habitats are conserved; there is prohibition on the hunting, fishing, capturing, harassing and deliberate killing of the species; and the projects activities do not seriously hinder migration of the species.

2.7.2 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973

The convention requires the signatories to impose strict regulation (including penalisation, confiscation of the specimen etc.) regarding trade of all species threatened with extinction or that may become so, in order not to endanger further their survival. In view of the threats to the species covered in the Convention, all hydropower projects should evaluate impacts on the species and adopt mitigation measures necessary to bring the impacts to acceptable levels

2.7.3 Climate Change Convention 1992

The convention aims at stabilizing greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. To achieve the objective of the convention, all parties are generally required to develop national inventories of emission and formulate and implement national and regional programmes of mitigation measures.

2.7.4 Biodiversity Convention 1992

The Convention on Biological Diversity was negotiated under the auspices of the United Nations Environment Programme (UNEP). Article 25 of the CBD establishes a Subsidiary Body on Scientific, Technical and Technological Advice to provide all parties with "timely advice" relating to implementation of the Convention. The CBD deals with issues such as the monitoring and assessment of biodiversity, practical approaches to taxonomy, economic valuation of biodiversity, access to genetic resources, agricultural biodiversity, terrestrial biodiversity, marine and coastal biodiversity and bio-safety.

The relevance of this convention to hydropower projects becomes apparent since they will always introduce interference with biological sources such as land, vegetation and forests, and dam construction and operations may contribute directly or indirectly to various environmental problems ranging from air pollution to climate change.

2.7.5 The Rio Declaration

The Rio Declaration comprises twenty seven principles which address such important issues as: sustainable development to integrate environmental protection into the development process; common but differentiated responsibilities to conserve, protect and restore the earth's ecosystems; public participation and information access at the national level, reduce and eliminate unsustainable patterns of production and consumption.

2.7.6 Agenda 21

Agenda 21 is a blueprint and action plan for international cooperation towards sustainable development. It is important to note that Agenda 21 makes particular reference to dam operations, which encourages states to assess the need for additional measures to protect the riparian environments against pollution arising from hydropower projects.

2.7.7 Conventions on Wetlands (Ramsar Convention)

The broad aim of the Convention on Wetlands (Ramsar, Iran, 1971) is to halt the worldwide loss of wetlands and to conserve those that remain through wise use and management. This requires international cooperation, policymaking, capacity building and technology transfer. Contracting Parties have made commitments to:

- Designate at least one site that meets the Ramsar criteria for inclusion in the List of Wetlands of International Importance
- Protect the ecological character of listed sites
- Include wetland conservation within their national land-use planning
- Establish nature reserves on wetlands and promote wetland training.

2.7.8 Convention to Combat Desertification and Drought (CCD)

The stated objective of the Convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. Most of the endangered dryland regions lie near the world's five main desert areas of which the Sahara Desert extending from the Atlantic shore to the Red Sea coast. High Aswan Dam, Merowe and Low Dal and sites at other cataracts are in this zone.

2.8 EGYPT - LEGAL AND INSTITUTIONAL FRAMEWORK

2.8.1 Institutions with Responsibilities for Water Quality

The institutions involved with water quality management in Egypt are generally line-management ministries with responsibilities in areas that are related to, but not necessarily coincident with environmental protection. The Ministry of Health and the Ministry of Industry have many other functions, many of which conflict with water quality management. Egypt lacks such a relatively strong central coordinating or managing body, although the Egyptian Environmental Affairs Agency (EEAA) has some of the appropriate rules (coordination, studies and evaluation). The following outlines institutions with major roles in water quality management.

2.8.2 Ministry of Water Resources and Irrigation (MWRI)

The MWRI is formulating the national water policy to face the problem of water scarcity and water quality deterioration. The overall policy's objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country. Under law No. 12 of 1984, MWRI retains the overall responsibility for the management of all water resources, including available surface water resources of the Nile system, irrigation water, drainage water and groundwater.

The MWRI is the central institution for water quality management. The main instrument for water quality management is Law 48. The MWRI is responsible to provide suitable water to all users but emphasis is put on irrigation. It has been given authority to issue licenses for domestic and industrial discharges. The responsibility to monitor compliance to these licenses through the analyses of discharges has been delegated to MOHP.

The National Water Research Centre (NWRC) supports the MWRI in its management. Within the NWRC, three institutes are focusing on the Nile, the irrigation and drainage canals and groundwater (NRI, DRI, RIGW). NWRC maintains a national water quality monitoring network and contracts portions of the monitoring activity to these institutes. NWRC also operates a database where all MWRI water quality data is consolidated. NWRC also operates a modern, well equipped water quality laboratory.

2.8.3 Egyptian Environmental Affairs Agency (EEAA)

The central organization for environmental protection is the EEAA. This agency has an advisory task to the Prime Minister and has prepared the National Environmental Action Plan of Egypt 2002/17 (2002). The Minister of State for Environment heads the agency. According to Law 4, it has the enforcing authority with respect to environmental pollution except for fresh water resources. Through Law 48, the MWRI remains the enforcing authority for inland waterways.

The EEAA is establishing an Egyptian environmental information system (EEIS) to give shape to its role as coordinator of environmental monitoring. Moreover, staff is being prepared to enforce environmental impact assessment (EIA). Major industries have been visited in view of their non-compliance with respect to wastewater treatment. Compliance Action Plans (CAP's) are being agreed upon to obtain a grace period for compliance. Additionally EEAA is monitoring waste from Nile ships and is responsible for coastal water monitoring. In cooperation with the MWRI, an action plan was implemented to reduce industrial pollution of the Nile.

2.8.4 Ministry of Health and Population (MOHP)

The MOHP is the main organization charged with safeguarding drinking water quality and is responsible for public health in general. Within the framework of Law 48/1982, this Ministry is involved in standard setting and compliance monitoring of wastewater discharges. The Environmental Health Department (EHD) is responsible for monitoring with respect to potable water resources (Nile River and canals). The MOHP samples and analyses all intakes and treated outflows of drinking water treatment plants. Also water from drinking water production wells is monitored. In case of non-compliance of drinking water quality, especially with respect to bacterial contamination, MOHP takes action.

Within the framework of Law 48 MOHP samples and analyses drain waters to be mixed with irrigation waters, industrial and domestic wastewater treatment plant effluents and wastes discharged from river vessels. In case of non-compliance of discharges, the MWRI generally takes action upon notification from the MOHP.

2.8.5 Ministry of Housing, Utilities and New Communities (MHUNC)

Within the Ministry of Housing, Utilities and New Communities, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) has the responsibility for planning, design and construction of municipal drinking water purification plants, distribution systems, sewage collection systems, and municipal wastewater treatment plants. Once the facilities have been installed, NOPWASD organizes training and then transfers the responsibilities for operation and maintenance to the regional or local authorities.

2.8.6 Ministry of Agriculture and Land Reclamation (MALR)

MALR develops policies related to cropping patterns and farm production. Moreover they are in charge of water distribution at field level and reclamation of new agricultural land. With respect to water quality management issues, their policies on the use and subsidy reduction of fertilizers and pesticides is important. In addition, MALR is responsible for fisheries and fish farms (aquaculture).

The Soil, Water and Environment Research Institute is part of the MALR and is responsible for research on many subjects such as water and soil quality studies on pollution, bioconversion of agricultural wastes, reuse of sewage wastewater for irrigation, saline and saline-alkaline soils, fertilizer and pesticide use and effects.

2.9 EGYPT - POLICY FRAMEWORK

2.9.1 Egypt’s Agricultural policy up to 2017

A Land Master Plan of Egypt was prepared in 1986. It concluded that the construction of AHD not only made the intensification of agriculture feasible in the old lands but also extended it to new “reclaimed” areas. Some 650 000 fedddans out of 805 000 feddans of land reclaimed during 1960-70 was made possible due to the increased supply of water from AHD. The total land that could be reclaimed is subject to water availability. The arable area per person declined by 75% from 0.51 feddan/person to 0.13 feddan/person during 1887-1990 (Abu Zeid and Rady 1991).

The strategy for agricultural development up to 2017 has a number of aims.

(i) To increase the annual rate growth in the agricultural production from 3.4% to 3.8% during the remaining period of the Fourth 5-Year Plan, and to 4.1% annually up to 2017. This goal is attainable only through vertical and horizontal expansion of plant and animal production, which will have a positive bearing on job creation, income to producers and the overall standard of living of the rural population.

(ii) To reclaim no less than 150,000 feddans annually, within the Master Plan of Egypt's Land and water resources which assesses the reclaimable and cultivable lands in the Delta, Southern Valley, East Owaynat, the area of and round Lake Nasser and East and West of Suez Canal by the year 2017 at about 3.4 million feddans. The inhabited area would reach 25% of the total area of Egypt.

(iii) To increase the agricultural production horizontally and vertically through the efficient allocation and use of soil and water resources. Maintenance and development of the natural resource base is an integral part of Egypt's sustainable agricultural development program.

(iv) To form a national strategic stock of the basis food commodities by focusing on the efficient use of the available resources and redirecting investments to such areas that help fulfill the increasing food needs of the population. This shall be accompanied with rationalization of food consumption levels, reduction of post-harvest losses.

2.9.2 Water Policy

The Ministry of Water Resources and Irrigation (MWRI) has prepared a National Water Policy till the year 2017 including three main themes:

- optimal use of available water resources;
- development of water resources; and
- protection of water quality and pollution abatement.

At present, Egypt is addressing the issue of limited water quantity by managing the demand side. MWRI formulated a water master plan in 1981. This plan is currently updated. The process of updating the water master plan aims to allocate available water resources according to various needs and demands that are feasible from the economic perspective. It also aims to gain social acceptance and political support. The Water Master Plan is updated through the National Water Resources Plan (NWRP) project.

The NWRP has been operated since 1998 and jointly funded between MWRI and the Netherlands Government. This project is directed towards developing a National Water Resources Plan that describes how Egypt will safeguard its water resources both quantity and quality and how it will optimize the use these resources in response to the socio-economic and environmental conditions.

2.10 EGYPT - NON-GOVERNMENT ORGANISATIONS WORKING IN THE AREA OF LAKE NASSER

2.10.1 Centre for Development Services (CDS)/Desert Development Centre (DDC) – American University in Cairo

The CDS is a Cairo based NGO established in 1990 and together with the DDC of the American University in Cairo are the implementing agencies for the "Agro-Ecology West of Lake Nasser - Towards a Sustainable Livelihoods Strategy" Project. The High Dam Lake Development Authority (HDLDA) is a strategic partner. The Canadian International Development Research Centre (IDRC) is the main funding agency.

The NGO is working in three of the settlement communities on the western shores of Lake Nasser: Khor Galal, Kalabsha, and Garf Hussein: numbered 4, 5 and 6 respectively of Map 8. The project is an Action Research project using a trans-disciplinary and multi-stakeholder approach to encourage sustainable improvements to household incomes and positive environmental actions that will enhance human health and community welfare. The project is being implemented over three years. It commenced in July 2004 and is due for completion in July 2007. Total funding is CAD$ 478,760.

They project is focusing on (i) action research into environmentally safe methods of pest control and fertilization, (ii) marketing and (iii) human and animal health.

The project is also working with the University of the South Valley and Suez Canal University.

2.10.2 Egyptian Swiss Development Fund (ESDF)

The ESDF is also working in other Settlement communities west of the Lake. It also covers agricultural extension and research and health aspects. It also supports capacity building for the Community Development Associations (CDA's) – the elected bodies that are involved with the day-to-day management of the Schemes.

2.10.3 World Food Programme (WFP)

WFP's Food Aid project directly supports the establishment of the Settlement Schemes from a physical perspective. It has its own field staff in the same areas as CDS and ESDF. As with CDS and ESDF they also provide capacity building support to the CDA's.

2.10.4 Wadi Allaqi Project: Universities of the South Valley in Aswan and Glasgow, U.K.

This project has been running since the late 1980's and is collaborative research link between the University of the South Valley in Aswan and the University of Glasgow in the UK. It is funded by UK DiFID's Academic Links and the Gender and Development programmes.

It focuses on the peoples' livelihoods in the Wadi Allaqi and studies the changes in their livelihood strategies under changing environmental conditions due to the formation of Lake Nasser. It has studied in depth indigenous knowledge of both men and women, livelihood strategies of women headed households and the natural resource management systems in the Wadi.

2.11 AFRICAN DEVELOPMENT BANK’S ENVIRONMENTAL POLICY

The African Development Bank’s (AfDB) environmental policy was approved in 1990 and its environmental assessment guideline followed in 1992. The Bank has continually updated its environmental policy and its social and environmental study guidelines. AfDB’s updated policy on environment was issued 2004, incorporating and redefining environmentally sustainable development. The Bank’s development plan seeks to ensure that environmental management tools like strategic impact assessment and project level environmental and social assessment will be used systematically to monitor environmental performance and encourage community involvement. With regard to sustainable energy development, the Bank has identified the need to refocus its instruments and policy to deliver sustainable, reliable and environmentally friendly energy resource development. The proposed hydropower project under study is in line with the Bank’s policy in relation to sustainable and environmentally friendly energy resource development.

In line with the updated policy, two relevant guidelines, namely the Strategic Impact Assessment Guideline and the Integrated Environmental and Social Assessment Guideline that were produced in 2004, were used for guiding the present pre-feasibility study and preparation of TOR for a future feasibility study. Based on the nature, scale and identified impacts the project can be categorized as Category 1. According to the AfDB, Category 1 projects that proceed to full feasibility study and implementation require a full Environmental and Social Impact Assessment (ESIA), including the preparation of an Environmental and Social Management Plan (ESMP). The ESIA examines the project’s potential beneficial and adverse impacts in detail and recommends any measures needed to prevent, minimise, mitigate or compensate for adverse impacts and to enhance environmental and social project benefits. The Bank provides special attention to public participation in the environmental study process through conducting meaningful consultations with relevant stakeholders, including potential beneficiaries, affected groups, Civil Society Organisations (CSOs) and local authorities, about the project’s environmental and social aspects and take their views into account.

2.12 WORLD BANK’S SAFEGUARD POLICIES

The World Bank has developed a series of safeguard policies to help promote socially and environmentally sustainable approaches to development as well as to ensure that Bank operations do not harm people and the environment. These safeguard policies include the Bank's policy on Environmental Assessment (EA) and those policies that fall within the scope of EA. These have been considered in relation to the Mandaya project and their applicability is summarized as follows:

Safeguard policies on Environmental Assessment, International Waterways, Involuntary Resettlement, Natural Habitats and Safety of Dams apply to the Mandaya project.

Safeguard policies on Physical Cultural Resources and Forestry may apply to the Mandaya project.

Safeguard policies on Indigenous Peoples, Pest Management and Disputed Areas are considered not applicable to the Mandaya project.

For future funding purposes, it is intended that the present scoping/IEA report should reflect the current policies, requirements and guidelines of the World Bank. The 10 safeguard policies are outlined below. By examining these in relation to the Mandaya project in this initial environmental assessment report, it is also intended to build up confidence and trust in all stakeholders that these important issues will be addressed in detail in future phases of study.

2.12.1 Environmental Assessment (OP 4.01)

Environmental Assessment is one of the 10 environmental, social, and legal safeguard policies of the World Bank. Environmental Assessment is used in the World Bank to identify, avoid, and mitigate the potential negative environmental impacts associated with Bank lending operations. This policy is considered to be the umbrella policy for the Bank's environmental 'safeguard policies'.

The Operational Policy (OP) and Bank Procedure (BP) 4.01 on Environmental Assessment (EA) published in January 1999, applies to the Mandaya project. The Mandaya project is determined as Category ‘A’, requiring a full EIA in future.

Annexes of the OP define the required structure of the EIA report and the structure of the Environmental Management Plan (EMP) with which the future EIA report must comply.

OP 4.01 states that for Category ‘A’ projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the developer should normally engage an advisory panel of independent, internationally recognized environmental specialists to advise on all aspects of the project relevant to the EA.

In relation to public consultation, OP 4.01 requires a two-stage process:

a) shortly after environmental screening and before the terms of reference for the full EIA are finalised, and

b) once a draft EIA report is prepared.

In addition, the borrower is required to consult with stakeholder groups throughout project implementation as necessary to address EIA-related issues that affect them.

2.12.2 Projects on International Waterways (OP 7.50)

This policy applies to the Mandaya hydropower project because the Abbay/Blue Nile/Main Nile flows through two or more states.

The Bank recognizes that the cooperation and goodwill of riparians is essential for the efficient use and protection of international waterways. Therefore, it attaches great importance to riparians' making appropriate agreements or arrangements for these purposes for the entire waterway or any part thereof. The Bank stands ready to assist riparians in achieving this end. In cases where differences remain unresolved between the state proposing the project (beneficiary state) and the other riparians, prior to financing the project the Bank normally urges the beneficiary state to offer to negotiate in good faith with the other riparians to reach appropriate agreements or arrangements.

It is noted that this process has effectively begun by World Bank already being a stakeholder in promoting NBI and ENTRO's pursuit of viable projects including these relating to power trading.

2.12.3 Involuntary Resettlement (OP 4.12)

This policy applies to the Mandaya hydropower project because involuntary resettlement will be required.

Any requirement for involuntary resettlement is considered to be one of the most important environmental impacts of a proposed project, and Bank guidance on resettlement and compensation is now very comprehensive and specific, particularly in relation to the identification, participation and support of project-affected persons (PAPs). The policy objectives stated in OP 4.12 are as follows:

- Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs;
- Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs;
- Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

The "Involuntary Resettlement Sourcebook: Planning and Implementation in Development Projects", comprising some 468 pages published in 2004, is the authoritative document which clarifies many policy and technical issues that confront resettlement policymakers and practitioners. It provides guidance on resettlement design, implementation, and monitoring, recognizing that construction of road and dam infrastructure (considered a pre-requisite for sustained socioeconomic growth in

ENTRO's power trade projects) requires acquisition of land and, therefore, physical relocation and economic displacement of people.

2.12.4 Natural Habitat (OP 4.04)

This policy may be triggered by the Mandaya project. It states that wherever feasible, Bank-financed projects are sited on lands already converted (excluding any lands that in the Bank's opinion were converted in anticipation of the project). The Bank does not support projects involving the significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment indicates that a project would significantly convert or degrade natural habitats, the project should include mitigation measures acceptable to the Bank. Such mitigation measures include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The Bank encourages borrowers to incorporate into their development and environmental strategies, analyses of any major natural habitat issues, including the identification of important natural habitat sites, the ecological functions they perform, the degree of threat to the sites, priorities for conservation, and associated recurrent-funding.

Inundation of the Mandaya reservoir basin will clearly 'convert or degrade' its natural habitat. The question is whether that can be considered 'critical' natural habitat. The World Bank definition of critical natural habitat is as follows:

Existing protected areas and areas officially proposed by governments as protected areas (e.g., reserves that meet the criteria of IUCN classifications), areas initially recognized as protected by traditional local communities (e.g., sacred groves), and sites that maintain conditions vital for the viability of these protected areas (as determined by the environmental assessment process);or sites identified on supplementary lists prepared by the Bank or other authoritative sources. Such sites may include areas recognized by traditional local communities (e.g. sacred groves); areas with known high suitability for biodiversity conservation; and sites that are critical for rare, vulnerable, migratory, or endangered species. Listings are based on systematic evaluations of such factors as species richness; the degree of endemism, rarity, and vulnerability of component species; representativeness; and integrity of ecosystem processes.

If an EIA indicates that a project would significantly convert or degrade natural habitats, the project must include mitigation measures acceptable to the Bank. Such mitigation measures may include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and the establishment and maintenance of an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The Bank takes into account the borrower's ability to implement the appropriate conservation and mitigation measures. If there are potential institutional capacity problems, the project must include components that develop the capacity of national and local institutions for effective environmental planning and management.

2.12.5 Dam Safety (OP 4.37)

This policy will be triggered by the Mandaya project. For the life of any dam, the owner is responsible for ensuring that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the Bank is concerned about the safety of new dams it finances and existing dams on which a Bank-financed project is directly dependent.

When the Bank finances a project that includes the construction of a new dam, it requires that the dam be designed and its construction supervised by experienced and competent professionals. It also requires that the borrower adopt and implement certain dam safety measures for the design, bid tendering, construction, operation, and maintenance of the dam and associated works.

The Bank distinguishes between small and large dams. The proposed Mandaya dam is a large dam being “15 metres or more in height”. For large dams, the Bank requires

a) reviews by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations;

b) preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan;

c) pre-qualification of bidders during procurement and bid tendering, and

d) periodic safety inspections of the dam after completion.

The Panel consists of three or more experts, appointed by the borrower and acceptable to the Bank, with expertise in the various technical fields relevant to the safety aspects of the particular dam. The primary purpose of the Panel is to review and advise the borrower on matters relative to dam safety and other critical aspects of the dam, its appurtenant structures, the catchment area, the area surrounding the reservoir, and downstream areas. However, the borrower normally extends the Panel’s composition and terms of reference beyond dam safety to cover such areas as project formulation; technical design; construction procedures; and, for water storage dams, associated works such as power facilities and river diversion during construction.

The borrower contracts the services of the Panel and provides administrative support for the Panel’s activities. Beginning as early in project preparation as possible, the borrower arranges for periodic Panel meetings and reviews, which continue through the investigation, design, construction, and initial filling and start-up phases of the dam. The borrower informs the Bank in advance of the Panel meetings, and the Bank normally sends an observer to these meetings. After each meeting, the Panel provides the borrower a written report of its conclusions and recommendations, signed by each participating member; the borrower provides a copy of that report to the Bank. Following the filling of the reservoir and start-up of the dam, the Bank reviews the Panel's findings and recommendations. If no significant difficulties are encountered in the filling and start-up of the dam, the borrower may disband the Panel.

2.12.6 Physical Cultural Resources OP/BP 4.11

This policy may be triggered by the Mandaya project. Cultural resources are important as sources of valuable historical and scientific information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices. The loss of such resources is irreversible, but fortunately, it is often avoidable. The objective of OP/BP 4.11 on Physical Cultural Resources is to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

The United Nations term "cultural property" includes sites having archaeological (prehistoric), palaeological, historical, religious, and unique natural values. Cultural property, therefore, encompasses both remains left by previous human inhabitants (including middens, shrines, and battlegrounds), and unique natural environmental features such as canyons and waterfalls. The World Bank requires that, before proceeding with a project that may risk damaging cultural property (e.g., any project that includes large scale excavations, movement of earth, superficial environmental changes or demolition), the cultural property aspects of the project site must be determined. If there is any question of cultural property in the area, a reconnaissance survey should be undertaken in the field by specialists.

2.12.7 Forests (OP 4.36)

This policy may be triggered by the Mandaya project. Whilst this policy is principally related to World Bank activities in the forestry sector, it includes policies on the conservation of forest biodiversity, the sustainable management of forest areas, and the participation of local people particularly in the management of the surrounding forests. The policy emphasizes that the management, conservation, and sustainable development of forest ecosystems and their associated resources are essential for lasting poverty reduction and sustainable development.

The policy states that:

- The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical forest areas or related critical natural habitats;

- If a project involves the significant conversion or degradation of natural forests or related natural habitats that the Bank determines are not critical, and the Bank determines that there are no feasible alternatives to the project and its siting, and comprehensive analysis demonstrates that the overall benefits from the project substantially outweigh the environmental costs, the Bank may finance the project provided that it incorporates appropriate mitigation measures.

This policy overlaps with that on Natural Habitat (OP 4.04) to a great extent. In Mandaya's case, if woodland issues are not considered covered by Natural Habitat (OP 4.04), it would cover roads, reservoir basin clearance/inundation and transmission lines through woodlands (if indeed concerned Combretum woodlands and open woodlands are regarded as forests).

2.12.8 Indigenous Peoples (OP 4.20)

This Operational Policy provides policy guidance to ensure that indigenous people benefit from development projects, and to avoid or mitigate potentially adverse effects on indigenous people caused by Bank-assisted activities. Special action is required where Bank investments affect indigenous peoples, tribes, ethnic minorities, or other groups whose social and economic status restricts their capacity to assert their interests and rights in land and other productive resources. The Bank defines "indigenous peoples," "indigenous ethnic minorities," "tribal groups," and "scheduled tribes" as social groups with a social and cultural identity distinct from the dominant society that makes them vulnerable to being disadvantaged in the development process.

Whilst the people living in the vicinity of Mandaya are from more than one recognisable tribe, and are extremely poor, vulnerable and in need of great care concerning resettlement and restoring/improving livelihoods, none can be described as indigenous peoples under the above definition. Currently, this policy is not expected to be triggered by the project.

2.12.9 Pest Management (OP 4.09)

Rural development and health sector projects have to avoid using harmful pesticides. A preferred solution is to use Integrated Pest Management techniques and encourage their use in the whole of the sectors concerned.

If pesticides are considered necessary at full EIA stage, either for crop protection at resettlement sites or in the fight against water-related vector-borne diseases, a Bank-funded project should include a Pest Management Plan (PMP), prepared by the borrower, either as a stand-alone document or as part of the Environmental Assessment. Currently, this policy is not expected to be triggered by the project.

2.12.10 Projects in Disputed Areas (OP 7.60)

The Mandaya project area is not in a disputed area and the Bank's policy on disputed areas will not be triggered by the project.

2.13 THE NILE WATERS TREATY

The Nile Waters Treaty (1959) had the following provisions:

- The average flow of the river is considered to be 84 BCM/yr. Evaporation and seepage were considered to be 10 BCM/yr., leaving 74 BCM/yr. to be divided.
- Of this total, acquired rights have precedence, and are described as being 48 BCM for Egypt and 4 BCM for Sudan. The remaining benefits of

approximately 22 BCM are divided by a ratio of 7 1/2 for Egypt (approx. 7.5 BCM/yr.) and 14 1/2 for Sudan (approx. 14.5 BCM/yr.). These allocations total 55.5 BCM/yr. for Egypt and 18.5 BCM/yr. for Sudan.

- If the average yield increases from these average figures, the increase would be divided equally. Significant decreases would be taken up by a technical committee, described below.
- Since Sudan could not absorb that much water at the time, the treaty also provided for a Sudanese water "loan" to Egypt of up to 1,500 MCM/yr. through 1977.
- Funding for any project which increases Nile flow (after the High Dam) would be provided evenly, and the resulting additional water would be split evenly.
- A Permanent Joint Technical Committee to resolve disputes and jointly review claims by any other riparian would be established. The Committee would also determine allocations in the event of exceptional low flows.
- Egypt agreed to pay Sudan £E 15 million in compensation for flooding and relocations.

3. PROJECT DESCRIPTION

3.1 PROJECT AREA

The Mandaya project site is located on the Abbay river some 20 km downstream of its confluence with the Didessa river. The catchment area for the Mandaya project comprises some 128,729 km^2 of the Blue Nile river basin (Figure 3.1 and Drawing No. M1, at end of report). The headwaters of the river are in the mountains surrounding Lake Tana. The Didessa river is one of the largest tributaries and drains an area to the west of Addis Ababa.

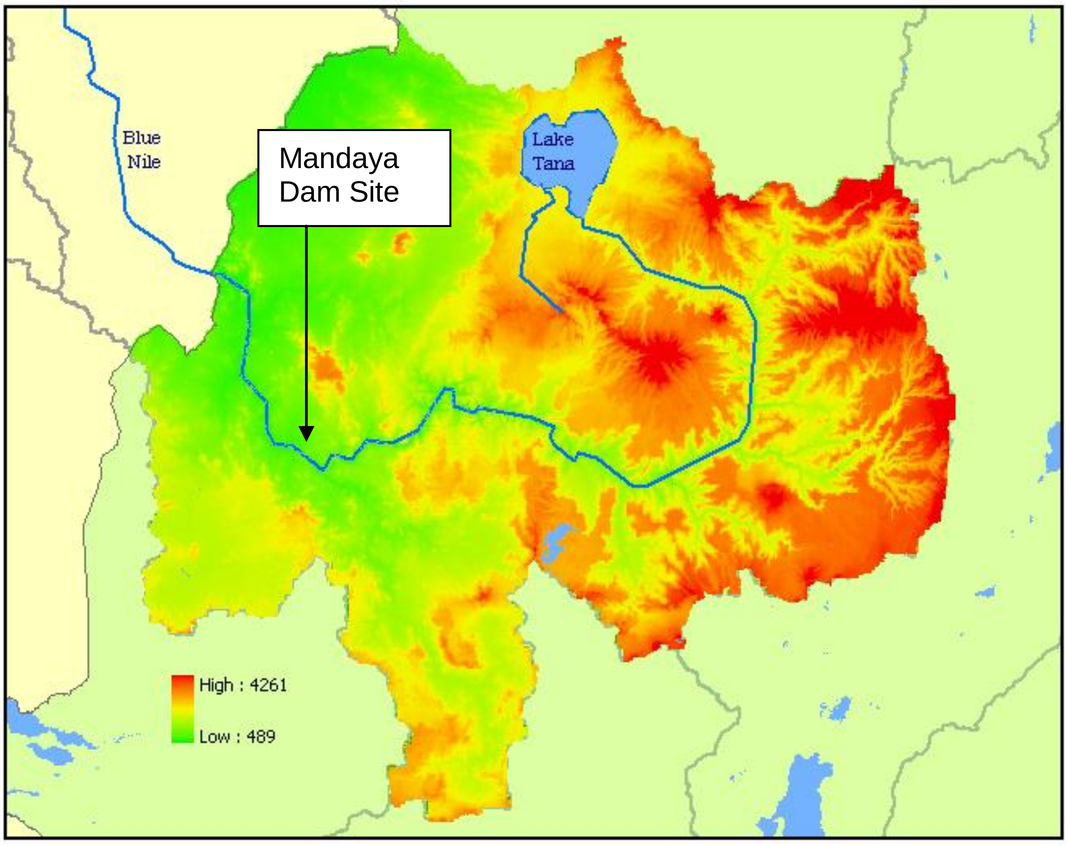


Figure 3.1 : Abbay River Basin

Much of the upper part of the basin comprises the highland plateau with elevation generally exceeding 2000 m. The plateau exhibits extensive level areas with intensive agriculture divided by incised valleys. The Abbay flows generally within a deeply incised gorge which has a relatively gentle gradient falling some 545 m over some 600 km from an elevation of El.1030 m at Kessie bridge to El. 485 m at the Sudan border.

3.2 DEVELOPMENT OPTIONS FOR BLUE NILE (ABBAY) RIVER

The United States Bureau of Reclamation, carried out a major study of the land and water resources of the Abbay/Blue Nile river basin in Ethiopia over the period 1960-1964. The study identified major hydropower development sites on the main river as follows (in order moving upstream from Sudan Border):

- Border
- Mandaya
- Mabil
- Karadobi

Table 3.1 summarises the key features of the Border, Mandaya and Mabil projects as defined by USBR. Information for the Karadobi project presented in Table 3.1 has been derived from the Pre-feasibility study report.

Table 3.1 : Characteristics of Potential Hydropower Projects on Blue Nile (USBR)

Site	Dam Height (m)	Full Supply Level (m)	Gross Storage ($m^3 \times 10^6$)	Installed Capacity (MW)	Energy Output (GWh/year)
Border	84.5	575	11,074	1400	6200
Mandaya	164	741	15,930	1620	7800
Mabil	171	906	13,600	1200	5314
Karadobi	250	1146	40,200	1600	9708

An initial review of the Mandaya project concluded that the site was suitable for development of a dam up to 260 m in height, with a full supply level of up to El. 860 m. The reconnaissance over flight in October 2007 revealed that the potential reservoir area appeared to be largely unpopulated. No roads, tracks or settlements were observed in the reservoir area. In general, the reservoir area was found to be covered with undisturbed open woodland.

Having ascertained that there was an opportunity to develop a higher reservoir at Mandaya than previously considered in the USBR studies in 1964, two options were considered for the long-term development of this reach of the Abbay river.

- Development of Mandaya to the maximum feasible elevation with full supply level of up to 860m in conjunction with the Karadobi development, developing the hydroelectric power potential of the river with two very large dams and reservoirs, or
- Development of Mandaya dam and reservoir (Drawing No. M2) to a lower elevation in conjunction with the Karadobi project and a third dam, which has been tentatively named Beko Abo, which could be developed in conjunction with a Mandaya reservoir full supply level elevation of El. 800 m.

The Beko Abo site lies some 2.5 km upstream of the existing bridge across the Abbay river on the Bure – Nekemte road. The Beko Abo site has various advantages compared to the Mabil site in that it would allow development of Mandaya to a higher elevation thus ensuring that the Mandaya reservoir has sufficient volume for effective regulation of inflows from the Abbay and Didessa rivers and avoids flooding of the Bure – Nekemte road bridge which would otherwise occur with the Mabil dam development.

Table 3.2 : Energy Output for Mandaya Project

FSL (m)	Minimum Operating Level (m)	Operating Range (m)	Installed Capacity MW	Gross storage $m^3 \times 10^6$	Live storage $m^3 \times 10^6$	Firm energy %	Generation Flow %	Spillage Flow %
741*	724.8	16.2	1600	16,200	5,600	52%	75.9	24.1
800	760	40	2000	49,200	24,600	92%	94.4	5.6
860	820	40	2400	106,700	41,400	95%	95.5	4.5

* USBR proposal

A development at Mandaya with a full supply level of El. 800m would capture some 93% of flow for energy generation with only 5% of flow lost to spillage. Firm energy generation would amount to 92% of total generation as a result of the improved flow regulation with live storage of 154% of mean annual flow. This development is superior to the lower level option proposed by USBR in terms of energy generation and provision of regulated flow downstream in Sudan.

For this study a full supply level of Mandaya reservoir of El. 800 m has been adopted allowing future development of the Beko Abo site as summarised in Table 3.3, below:

Table 3.3 : Characteristics of Proposed Hydropower Projects on Abbay

Site	Dam Height (m)	Full Supply Level (m)	Gross Storage ($m^3 \times 10^6$)	Installed Capacity (MW)	Energy Output (GWh/year)
Border	90	580	13,300	1200	6011
Mandaya	200	800	49,200	2000	12,119
Beko Abo	110	906	na	800 - 1000	na
Karadobi	250	1146	40,200	1600	9708

3.3 HYDROLOGY

The principal flow record for hydrological analysis for the Mandaya project is that for the Abbay river at Kessie (Station No. 2001). Mean annual flow at Mandaya over the 50 year period 1954-2003 has been estimated as 1013.5 m^3/s, taking account of future diversion of 77 m^3/s of flow from Lake Tana to the Beles Multi-purpose development.

Table 3.4 : Summary of Adopted Flow Series for Project Sites

Site	Catchment Area (km^2)	Mean Annual Flow (Natural) (m^3/s)	Mean Annual Flow (with Beles Diversion) (m^3/s)
Kessie	65,784	517	440
Karadobi	82,300	649	572
Mandaya	128,729	1091	1014
Border	176,918	1547	1547
El Deim		1547	1547

3.4 FLOOD STUDIES

Analysis of flood discharges has been carried out for the Abbay river at Kessie, Border and Deim. Based on this analysis, preliminary estimates of flood discharge have been determined for the Mandaya site for purposes of spillway design as shown in Table 3.5 below. A flood magnitude of 30,000 m^3/s has been adopted for spillway design.

Table 3.5 : Maximum Daily Discharge Estimates for Mandaya Site

Return Period (years)	Estimated Flood Magnitudes for Mandaya Site (m^3/s)
10,000	32,250
1,000	25,831
100	19,400
50	17,455
20	14,856
10	12,852

3.5 SEDIMENT

Measurements of sediment concentration in the Abbay / Blue Nile river have been carried out at Kessie and Border hydrometric stations in Ethiopia and at Diem in Sudan. Relatively few measurements have been made with some 27 measurements at Kessie over the period 1960 – 2004. Figure 3.2 below illustrates the sediment rating relationships for the periods 1960-61, 1985-95 and 2004.

Current sediment discharge at Kessie has been estimated based on measurements carried out in 2004 as shown in Table 3.6 and this has been used to derive an estimate for the Mandaya site (Table 3.7).

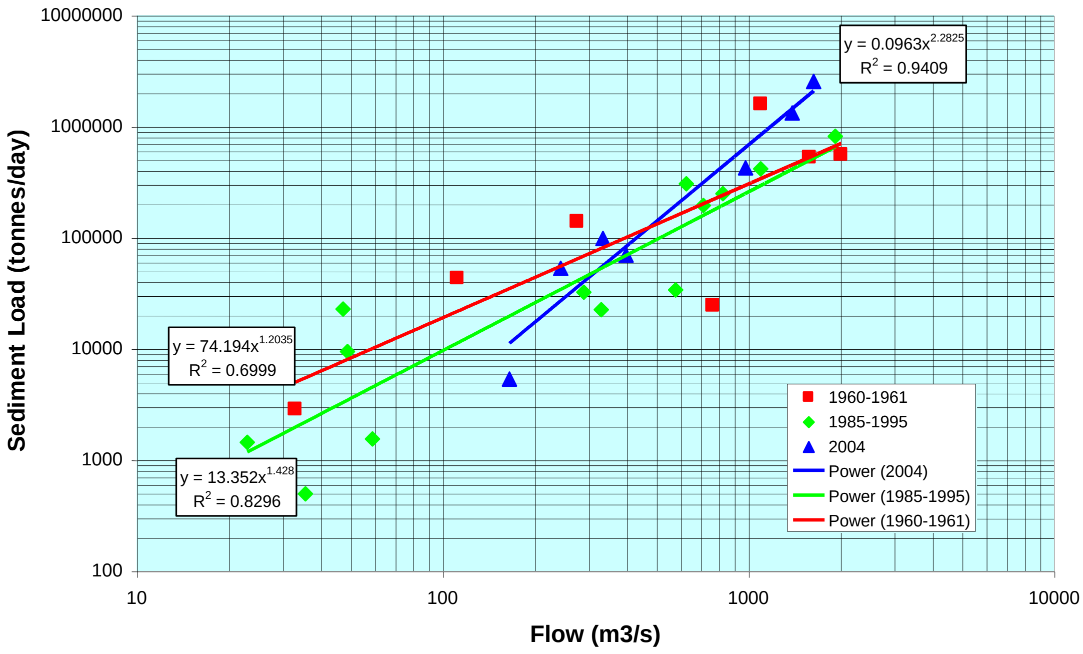


Figure 3.2 : Sediment Ratings for Abbay River at Kessie

Table 3.6 : Estimated Sediment Discharges at Kessie

Item	1960 – 1961 Data		2004 Data	
	Specific Sediment Discharge ($t/km^2/yr$)	Average Sediment Load (million tonnes / yr)	Specific Sediment Discharge ($t/km^2/yr$)	Average Sediment Load (million tonnes / yr)
Suspended sediment	901	59.3	2,791	183
Bedload (20%)		11.9		37
Total sediment discharge		71.2		220

Table 3.7 : Estimated Sediment Discharges at Mandaya

Location	Catchment Area (km^2)	Specific Suspended Sediment Discharge ($t/km^2/yr$)	Average Sediment Load* (million tonnes / yr)
Kessie*	68,074	2,791	220
Incremental catchment area Kessie to Mandaya	60,655	900	65
Mandaya	128,729		285

*based on data for Year 2004 including bedload

3.6 RESERVOIR AND POWER SIMULATION

Energy outputs of the Mandaya project and other development options on the Abbay/ Blue Nile have been determined using RAPSO, a river flow and energy model which simulates the entire Nile river system. Energy output for the recommended Mandaya project development with full supply level of El. 800m is presented in Table 3.8.

Table 3.8 : Energy Output of Mandaya Project

Option	Installed Capacity (MW)	Energy Output (GWh/year)			
		Base		With Mandaya	
		Firm	Average	Firm	Average
Karadobi	1,600	8,276	8,802		
Mandaya FSL 800	2,000	11,194	12,119		
Border	1,200	3,966	6,011	7,429	8,114
Low Dal	340		1,944		2,187
Uplift at Existing Power Stations	0				2,211
Uplift at Existing Power Stations	135*				2,657

* Additional plant at Roseires

A typical period 5-year of operation of the Mandaya project as simulated by RAPSO is illustrated in Figure 3.3.

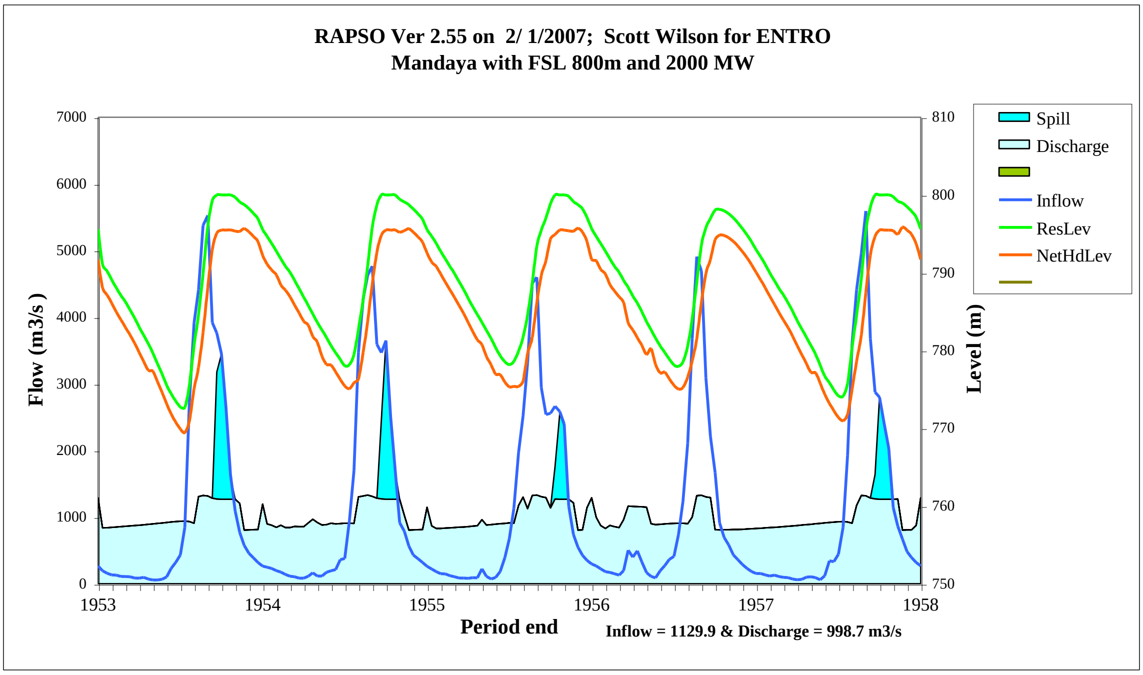


Figure 3.3 : Typical 5-year period operation of Mandaya

3.7 EFFECTS OF MANDAYA ON ENERGY GENERATION IN SUDAN

The effects of the Mandaya project on generation at existing hydropower projects in Sudan has been determined using the RAPSO model as illustrated in Table 3.9.

Table 3.9 : Uplift in Generation at Sudan Hydropower Projects due to Mandaya

Option	Average Energy Output GWh/year				
	Roseires	Sennar + Ext.	Merowe	Total	Uplift
Base Case, Existing with Roseires flushing operation	1436	302	5903	7640	0
With Mandaya, with Roseires flushing operation	2142	490	6263	8895	1255
With Mandaya, without Roseires flushing operation	2304	521	7026	9851	2211
Roseires MOL raised to El. 471 and 3 x 45 MW extension	2750	521	7026	10297	2657

3.8 EFFECTS OF MANDAYA ON FLOOD LEVELS IN SUDAN

Operation of the Mandaya project will alleviate flooding in Sudan as a result of the substantial degree of flow regulation. Figure 3.4, below illustrates that under a typical flood year water levels in Khartoum would be reduced by some 1.5 to 2 metres.

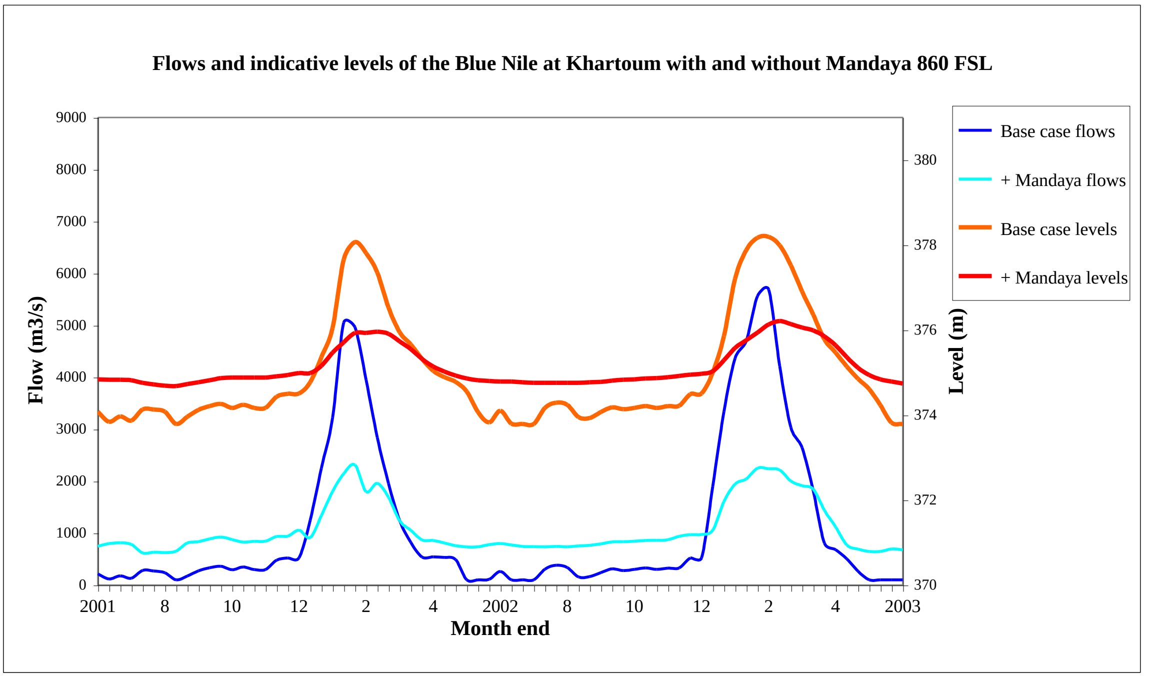


Figure 3.4 : Impact of Mandaya on Flood Levels in Khartoum

3.9 EFFECTS OF MANDAYA ON HIGH ASWAN IN EGYPT

The filling of the Mandaya reservoir will result in a reduction of water level in Lake Nasser / Nubia and consequently reduce the generating head at High Aswan power station. Figure 3.5 below illustrates the reduction in water level at High Aswan by some 12 metres that would be expected in the early years as Mandaya reservoir fills. Average reduction in energy generation at High Aswan over the 50-year simulation period due to the reservoir filling and operation of the Mandaya project has been calculated as 202 GWh/year, although the reduction in generation will be greater in the early years.

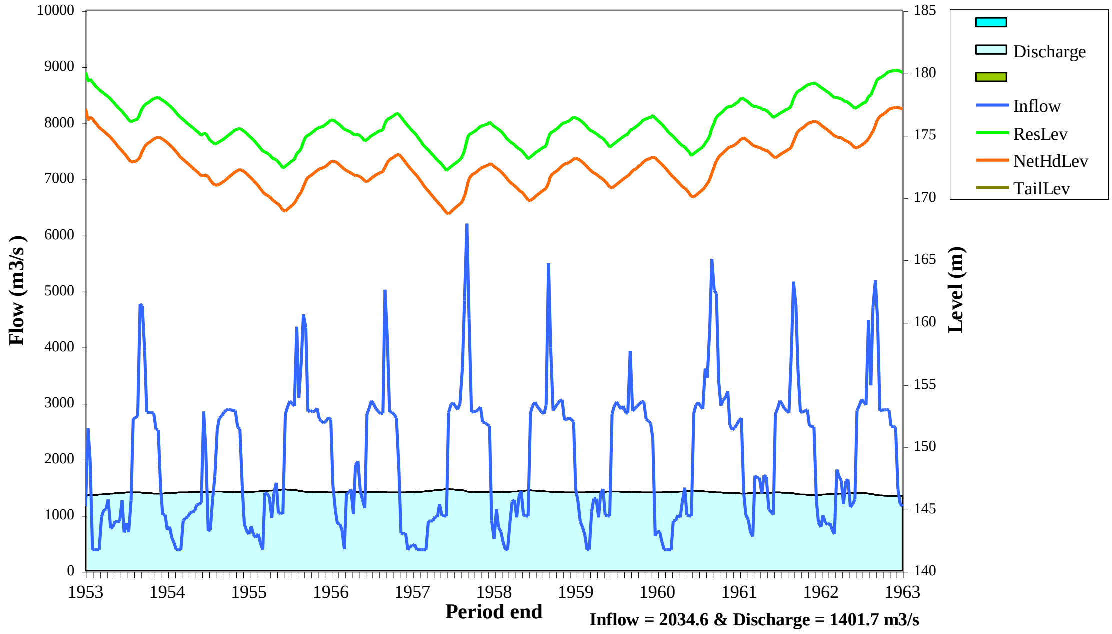


Figure 3.5 : Aswan 10-year Operation with Mandaya filling from January 1954

3.10 GEOLOGY OF MANDAYA SITE

Geological mapping at the Mandaya site confirmed the existence of the two major, broad geological formations divisions; namely the Precambrian, Biotite Gneissic Tonalite Formation and the late Tertiary Basalt Formation. The biotite gneissic tonalite is the foundation rock for the entire dam.

The typical rock mass condition, as seen in the scoured river section comprises unweathered to slightly weathered, and hard to very hard with weak foliation, sometimes the foliation is dispersed and the rock is geomechanically massive with estimated UCS in the range 150 to 200 MPa., with some degree of strength anisotropy caused by the foliation.

The river section is 400m wide at the centreline. There are many large, scoured outcrops of metatonalite at and nearby to the centreline. These indicate an unweathered very hard rock with incipient foliation and discontinuous vertical joints. The unconfined uniaxial strength of the rock material is high generally above 150 MPa. Such rock is considered uniform through the centreline area. These foundation conditions are considered to be excellent for the purpose of constructing an RCC dam, including all the various peripheral elements, such as diversion works, spillway and power station.

The Mandaya project area appears to be located in a relatively low seismic hazard zone. Mapping of seismic activity in Ethiopia and the neighbouring regions from 1906 until 2003 indicates that Mandaya dam site is 200km away from the nearest epicentre.

3.11 PROPOSED DESIGN OF MANDAYA DAM AND POWER STATION

Having regard to the site topography and geology at the Mandaya site, together with the substantial flows which must be accommodated both during construction and in the spillway facilities it is considered that an RCC dam is the most appropriate choice of dam type. The project layout is shown in Drawing No. M8.

The Mandaya dam with full supply level of El. 800 m will have an RCC volume of some 13 million cubic metres. As such it will be one of the largest volume RCC dams in the world. The rate of placing of the RCC will be of critical importance to the overall construction programme. Table 3.10 lists the planned and completed RCC dams that have had an average rate of placement in excess of 100,000 m^3/month. It should be noted that peak placing rates achieved at Longtan in China exceeded 400,000 m^3/month and therefore the proposed placing rate at Mandaya of 250,000 m^3/month appears to be achievable.

Table 3.10 : Average Placing Rates of Major RCC Dams

Dam	Height (m)	Volume of RCC (M m^3)	Placement period (months)	Average rate (m^3/month)
Basha Diamer (design stage)	285	10.50	32.3	325,000
Longtan	217	4.95	33.0	150,000
Upper Stillwater	91	1.13	9.0	125,325
Tha Dan	95	4.90	40.0	122,500
Olivenhain	97	1.07	8.8	121,895
Beni Haroun	118	1.69	16.4	102,860

The spillway will comprise 12 radial gates each 16 m wide by 18 m high, with a total discharge capacity of approximately 30,000 m^3/s with the reservoir at full supply level. The spillway gates have been sized to be capable of discharging the 1 in 10,000 year flood. It is recognised that incoming flood peaks will be significantly attenuated as the flood passes through the reservoir, particularly as the reservoir will normally be drawn down by 20 metres or more at the start of the flood season. In practice therefore, the selected discharge capacity of 30,000 m^3/s may be reduced during detailed feasibility level studies.

The power waterway system will comprise a reinforced concrete intake structure located on the main dam incorporating unitised intake gates and associated control equipment for each of the eight turbine-generator units. The intake structure will also be equipped with trash screens and trash raking mechanism, and slots to allow bulkhead gates to be deployed for gate, waterway and unit maintenance. Downstream of the intake eight surface-mounted steel penstocks descend the face of the dam and connect directly to individual turbine units.

The powerhouse will be a surface type structure of reinforced concrete and structural steel, construction, completely detached from the dam structure and located on the right bank. The powerhouse accommodates a loading/service bay, one bay for each of the 8 Francis turbine units, control block and offices.

The tailrace arrangement comprises an open channel that joins with the existing river approximately 350 m downstream of the powerhouse, and an RCC separation wall to limit the interferences between the tailrace channel and the spillway plunge pool.

The switchyard will be located on the right bank, downstream of the dam site, at a distance of approximately 500 m from the powerhouse.

3.12 MECHANICAL AND ELECTRICAL EQUIPMENT

The turbines will be vertical shaft Francis type with steel spiral casing. Each turbine will be directly connected to a vertical shaft synchronous generator. The water for each turbine will be supplied through a separate intake structure and penstock. Intake gates will be provided for emergency shutdown of the units. At the outlet, draft tube gates will be provided to permit dewatering of the turbine for inspection and maintenance purposes.

The rated output of each turbine will be 250 MW assuming a design net head of 171.9 m. The synchronous speed of the unit has been selected at 176.5 rpm. Each turbine will be equipped with an electronic digital type governor. The runner will have an approximate external diameter of 4.6 m and a height of approximately 1.9 m.

The generators will be of conventional air-cooled, self-ventilating type, with a rated capacity of approximately 288 MVA. Voltage will be in the range11–18 kV. The speed of each generator will be 176.5 rpm which corresponds to a 17 pole pairs generator.

The generators will be connected to single-phase transformers by metal-enclosed, isolated phase bus ducts. A coupling circuit breaker SF6 type (rated voltage 24 kV) would be provided to connect the generator to the grid through the generator transformers.

3.13 TRANSMISSION SYSTEM

It is envisaged that the transmission system would connect the Mandaya power station to both the Ethiopian and regional electricity network.

The connection to the Ethiopian grid would comprise either:

- 400 kV double circuit transmission line from Mandaya to Debre Markos following a route to the north side of the Mandaya reservoir (Length approximately 300 km),
- 400 kV double circuit transmission line from Mandaya to Sululta following a route to the south side of the Mandaya reservoir via Nekemte (Length approx. 450 km),

The connection to the Sudan grid would comprise:

- 500 kV double circuit transmission line from Mandaya to Hasaheisa or Rabak following a route to the west side of the Border reservoir site and west side of Roseires reservoir in Sudan (Length approximately 650 km).

3.14 ACCESS ROADS AND BRIDGES

A new access road will be required from the existing Addis Ababa to Asosa road to the Mandaya site. Improvement of the existing road from Addis Ababa to Mendi will be required to accommodate construction traffic and heavy loads.

Downstream of the Mandaya project a major multi-span bridge structure will be required across the Nile to permit construction access to the north bank and future connection to the existing road system north of the project location and Abbay river.

3.15 COST ESTIMATE

The cost of the Mandaya project has been estimated as USD 2,472 million inclusive of environmental mitigation measures. A breakdown of the project cost is given in Table 3.11.

Table 3.11 : Mandaya Project Cost Estimate

Item	Cost (Million USD)
Environmental Mitigation	22.0
Access Roads and Infrastructure	86.3
Reservoir Clearance	39.7
Civil Works	
Diversion works	60.6
RCC Dam and spillway	1,283.4
Powerhouse and tailrace	116.4
Switchyard and Buildings	5.5
Civil contingencies	219.9
Mechanical and Electrical Plant	334.4
Sub-total	
Engineering and Construction Management	216.8
Owners Administration	86.7
OVERAL TOTAL	2,471.7

3.16 CONSTRUCTION PROGRAMME

The Mandaya project will take some 8 years to commencement of generation of the first units. Final installation and commissioning of all 8 turbine-generator is anticipated to require 10 years from commencement of construction. The project construction schedule is given in Drawing No. M14.

Assuming that feasibility studies are carried out over the period 2008 – 2009, it is considered that the project could be completed by the end of year 2021.

3.17 CO_2 EMISSION SAVINGS

The Mandaya project will provide carbon emission savings of some 424 million tonnes of CO_2 compared to equivalent thermal generation based on a 50/50 gas-fired CCGT / coal fired thermal generation mix.

3.18 GENERATION PLANNING AND ECONOMIC APPRAISAL

The Mandaya hydropower project has been selected as part of the least cost development plan within the generation planning analysis for commissioning in approximately 2020 in advance of the Karadobi and Border projects.

The regional power trade development, including the interconnector linking Ethiopia to Sudan and Egypt, has been found to be economically attractive based on fuel cost savings in Sudan and Egypt in a loose pool arrangement with net benefits (10% discount rate) of up to USD 2,590 million as shown in Table 3.12, below.

Table 3.12 : Net Benefits of Generation Savings (Million USD)

$MUSD_{2008}$	SU : 700 MW, EG : 0 MW	SU : 700 MW, EG : 700 MW	SU : 700 MW, EG : 2000 MW	SU : 1200 MW, EG : 700 MW	SU : 1200 MW, EG : 2000 MW
Demand median - Fuel median	1 280	1 910	2 010	2 270	2 380
Demand median - Fuel low	840	1 120	1 340	1 520	1 520
Demand ET low - Fuel median	1 170	1 920	2 260	2 540	2 590
Demand ET high - Fuel median	820	1 140		1 550	1 600

3.19 KEY PROJECT CHARACTERISTICS

Power and Energy			
	Installed Capacity	2000 MW	
	Annual energy generation	Firm	11,194 GWh/yr
		Average	12,119 GWh/yr
	Plant factor	69%	
Hydrological data			
	Catchment area	128,729 km^2	
	Mean annual flow	1091 m^3/s (natural)	
		1014 m^3/s (with Beles diversion)	
Reservoir data			
	Full supply level	800 m	
	Minimum operating level	760 m	
	Operating range	40 m	
	Gross storage	49.2×10^9 m^3	
	Live storage	24.6×10^9 m^3	
	Surface area at FSL	736 km^2	
	Length of reservoir at FSL	300 km	
Dam			
	Type	Roller compacted concrete (RCC) gravity	
	Maximum height	200 m	
	Crest elevation	803 m	
	Crest length	1400 m	
	Dam volume	13,000,000 m^3	

Spillway		
	Type	Gated overfall with chute
	Design capacity	30,000 m^3/s
	Elevation of spillway crest	782 m
	No.of gate bays	12
	Size of gates (W x H)	16 m x 18 m
Power Intake		
	Sill elevation	743.8 m
	No. of intakes	8
	Gate size (W x H)	3 m x 5.4 m, 2 per unit
Penstocks		
	Number	8
	Diameter	5.4 m
	Length	246 m
Powerhouse		
	Type	Surface
	Overall length	217 m
	Overall width	22 m
	Generator floor level	616.5 m
	Access / loading bay level	631.5 m
Turbines		
	Type	Francis, vertical axis
	No.	8
	Speed	176.5 rpm
	Design net head	171.9 m
	Setting	605.39 m
Generator		
	Type	Vertical synchronous
	Size	288 MVA
Transmission within Ethiopia		
	Route	Mandaya to Debre Markos
	Length	300 km
	Voltage	400 kV ac
	Type	Double circuit
Transmission to Sudan		
	Route	Mandaya to Hasaheisa/Rabak
	Length	650 km
	Voltage	500 kV ac
	Type	Double circuit

4. EXISTING ENVIRONMENT OF PROJECT AREA

4.1 PHYSICAL ENVIRONMENT

4.1.1 Topographic and drainage features

Location and Access

Mandaya dam site is located on the Abbay river, 6.5 km upstream of its confluence with the Gember River, and 19km downstream of the Abbay/Didessa confluence (Drawing M5). The village of Boka in Sirba Abbay woreda is the last access point for vehicles. From Boka, access to the dam site is by foot, firstly walking 22 km along a foot path which crosses the Boka river and passes through the villages of Boka extension, Sirba Abbay, Abbay Goli, and then closely follows the river for about 4 km, before crossing rocky terrain for a further 3 km before descending to the confluence of the Abbay and Gember rivers (a full day's walk). The dam site lies a further 6.5 km upstream of the Gember confluence, through country which is quite open after grass burning, except for dense riverine thorn-thicket, the walk taking about 3 hours.

The coordinates of the Mandaya dam centre-line where it intersects the left bank of the river, according to GPS readings, are as follows:

Easting 36 P 0780819m, Northing UTM 1113849m, elevation 619m. The approximate river level on this centre line is 611m. The coordinates are based on GPS positional format of UTM/UPS, and map datum ADINDON. This is the same system used on the Ethiopian 1:50,000 scale topographic maps.

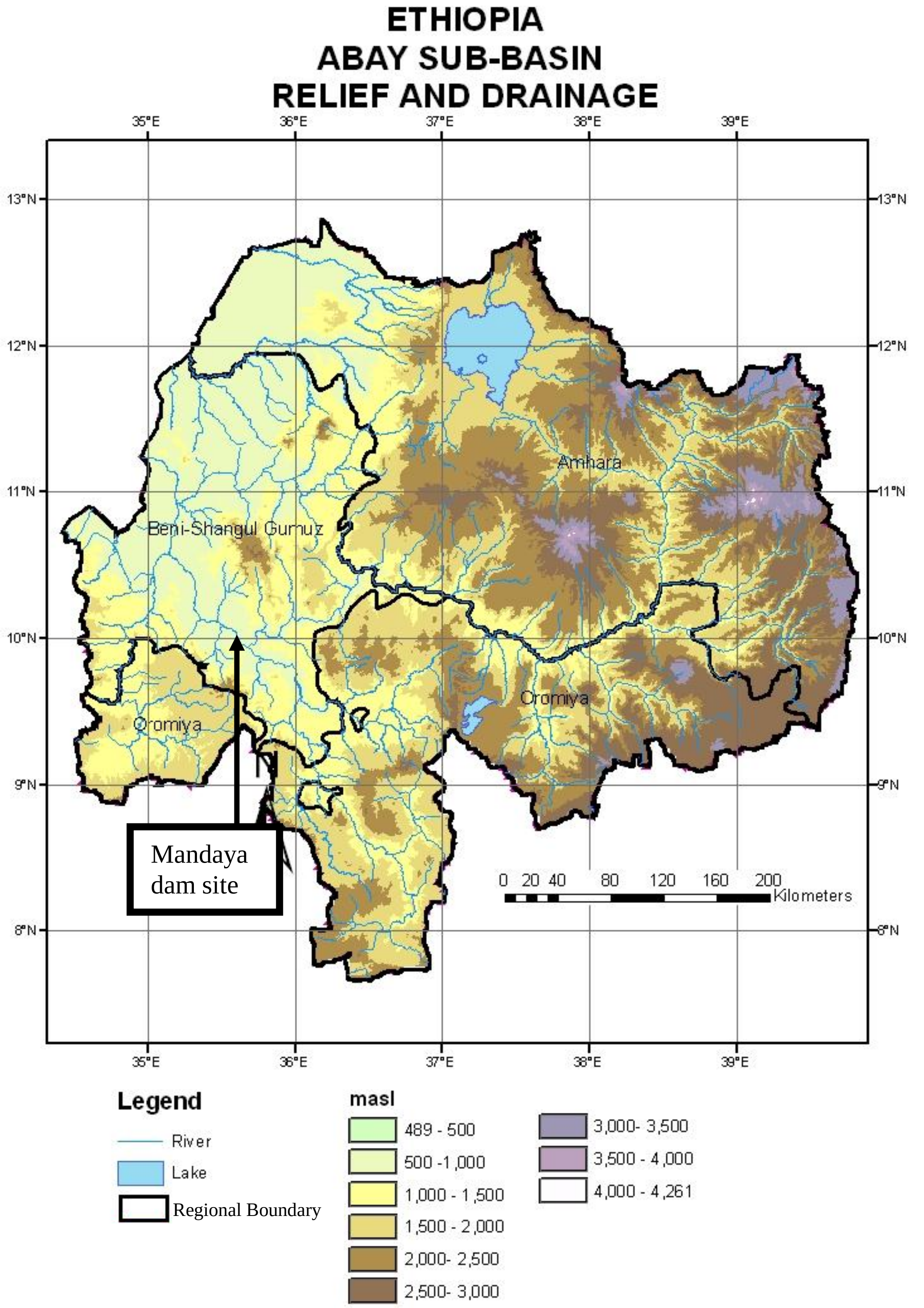
Mapping and Air Photographs

1:250,000 scale maps, sheets NC 36-8, and NC 36-12, NC 37-5 and NC 37-9, of series EMA 3, 1st edition, cover the dam site, upper basin and lower basin respectively. 1:50,000 scale topographic sheets are also available: sheet 1035 C4, 'Sirba Abay' covers the area downstream of the dam, whereas sheet 1035 D3, 'Re-Iti' covers the dam site. All adjacent 1:50,000 sheets that cover the upstream catchment area are available.

1:50,000 scale air photos (flown for USBR in 1957 and 1958) cover the dam site and surrounding area as follows: Strip M6, 1957, nos. 0025 & 0026, and 1430 to 1432; Strip M 7, 1958, nos. 0072 to 0076.

Abbay basin

After draining from Lake Tana, the Abbay river flows within a spectacular dissected gorge all the way to its confluence with Didessa. In this long reach, the whole geological sequence is preserved with Basement rocks overlain by Miocene sediment, overlain in turn by Tertiary flood basalt. In this section the river is relatively fast flowing with numerous rapids and waterfalls. The relief and principal drainage network of the basin are presented in Figure 4.1.



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006

Figure 4.1 : Abbay Sub-basin: Relief and Drainage

Downstream of the Abbay/Didessa confluence, the Abbay gorge is less spectacular. Downstream of the Mandaya dam site the gorge disappears. From here, the river has created a broad rolling pedeplain eroded into the pre-Cambrian Basement rocks. This plain extends all the way through Sudan with ever-decreasing river grade in the downstream direction. Remnants of plateau basalt rise above the pre-Cambrian terrain, usually forming “table-top” mountains, such as those seen around the Mandaya site.

The drainage pattern in the Precambrian terrain is trellised indicating structural control. Streams are eroded along preferential weakness paths such as faults, dykes and master joints.

The narrow U-shaped gorge at the Mandaya dam site extends 7 km upstream where the valley opens up due to the erosive effect of the Didessa and other tributaries. This topography and the very low grade of the riverbed provides a potentially huge reservoir basin area with very high storage volume (49.2 billion m3 at FSL 800 masl).

There are a series of rapids in the dam site reach, but no natural waterfall. The dam itself creates the head of the project for power generation.

4.1.2 Geology, minerals and soils

Geology

About 8 km downstream of the Abbay/Didessa confluence, the Abbay enters a well-defined narrow gorge that extends all the way to the Mandaya dam site, and continues a further 1.5 km where it abruptly terminates. From here on the river enters a broad dissected pedeplain, as mentioned previously. The narrow gorge at Mandaya is strongly controlled by geology. The gorge is cut through a flat layer of very strong durable basalt of Tertiary age. The horizontal basalt flow results in “table-top”, plateau, morphology. The edge of the plateau elements is formed by a vertical cliff of 15 to 45 m height, depending on the local thickness of the basalt flow. At the Mandaya site the top of the basalt on the left bank is at 901 masl and about 910 masl on the right bank side. Below the basalt caprock the Abbay has carved out a symmetric U-shaped valley in the underlying gneiss, with a distinct rocky river section of 300m width. The riverbed level is around 611m.

The valley flanks are corrugated with gullies that in their upper reaches expose decomposed metatonalite gneiss. Large boulders of basalt (up to 1,000 m^3 in volume) have detached from the upper escarpment and rolled down the steep valley slopes. Accumulations of boulders and talus are evident at the lower reaches of the side valley gullies.

Thus, the geology of the dam site comprises two major geological formations, namely the Precambrian (Biotite Gneissic Tonalite) and the late Tertiary (Basalt) Formations. The boundary of the two formations is easily mapped or delineated from air photos.

The Mandaya dam project area appears to be located in a relatively low seismic hazard zone. It is 200 km away from the nearest epicentre when compared with locations of all epicentres recorded from 1906 until 2003. The geophysical observatory of Addis Ababa University has identified seven 'seismo-tectonic' zones in Ethiopia which are areas of modern seismic activity. All of these zones are seismically unstable due to continuing movement along rift (normal) faults, and transform (wrench) faults, relating to crustal extension and concomitant plate collisions. The Mandaya dam site falls outside of these active zones. (See Figures 6.1, 6.2 and 6.3 in the Mandaya Engineering Pre-feasibility Report).

Minerals

The Precambrian rocks falling within the Abbay basin contain a significant proportion of greenstone rocks; these are ancient meta-sediments, marbles, and meta-volcanics having a low grade of metamorphism. The main green stone belt forms a broad swathe, about 20 to 50 km wide, and orientated north south, which intersects the Abbay river along a strip which is east of Najo, and west of Gimbi. This suite of rocks contains gold, and other base metals, disseminated within minor quartz veins. To date, no vein deposits have been found that are large enough to sustain gold mines. The gold over geological time is eroded away and ends up as tiny grains in the alluvial sands of the Abbay flood plain, and older river terraces. The Abbay river does not carry much coarse or medium grained sand. Instead the alluvium comprises mainly silt, very fine micaceous quartz sand, and channel lag gravels. Durable and heavy minerals, like gold and base metals tend to become incorporated into the channel lag gravels, where they form a loose, fine to medium grained, black sand-matrix, usually in pockets.

For a long time gold has been extracted from alluvium by local people that live next to the Abbay river and its major tributaries. The method of extraction is to sieve the channel lag gravels in order to concentrate the metallic rich sandy matrix. These matrix-fines are then panned to isolate the gold fraction. Every year the waters of the Abbay recede and it is during this period that panning is carried out. Annual flooding of the Abbay causes replenishment of the gold bearing sands as the channel lag deposits are re-distributed during maximum flow events.

The extent of the alluvial and primary gold resource in the Abbay basin is unknown and unknowable. During geological surveys for this study in February and March 2007, the geologist walked along 40 km of the Abbay River during the months of February and March 2007 (low flow months) and saw only two locations where gold was being extracted. One was close to Border dam site, and one at Abbay Goli village, downstream of Mandaya site. A combined total of about 40 people were busy panning.

Minor outcrops of marble may occur in the reservoir area, but if they do exist, they were too small to be individually mapped by the Ethiopian Geological Survey. Significant resources of high quality marble are found in the Koncho area downstream of Mandaya dam site. The quarry working areas are confined to elevated koppies

Construction Materials

A possible source of hard rock for aggregate would be pebble beds in the river alluvium particularly near the river channel. Such materials are found close to Abbay Goli where high river terrace deposits are found just east of this village. Gravels are also present on the islands north of Abbay Goli. These gravels are about 12 km downstream of the dam. A more reliable source of aggregate would be the basalt capping. This rock is considered as ideal for aggregate as it is very hard and durable, and homogenic. The basalt cap rock is considered to be 25m thick on average, and it appears to be quite unweathered throughout the layer. A very good quarry site could be established anywhere within the various plateau areas that are adjacent to the dam.

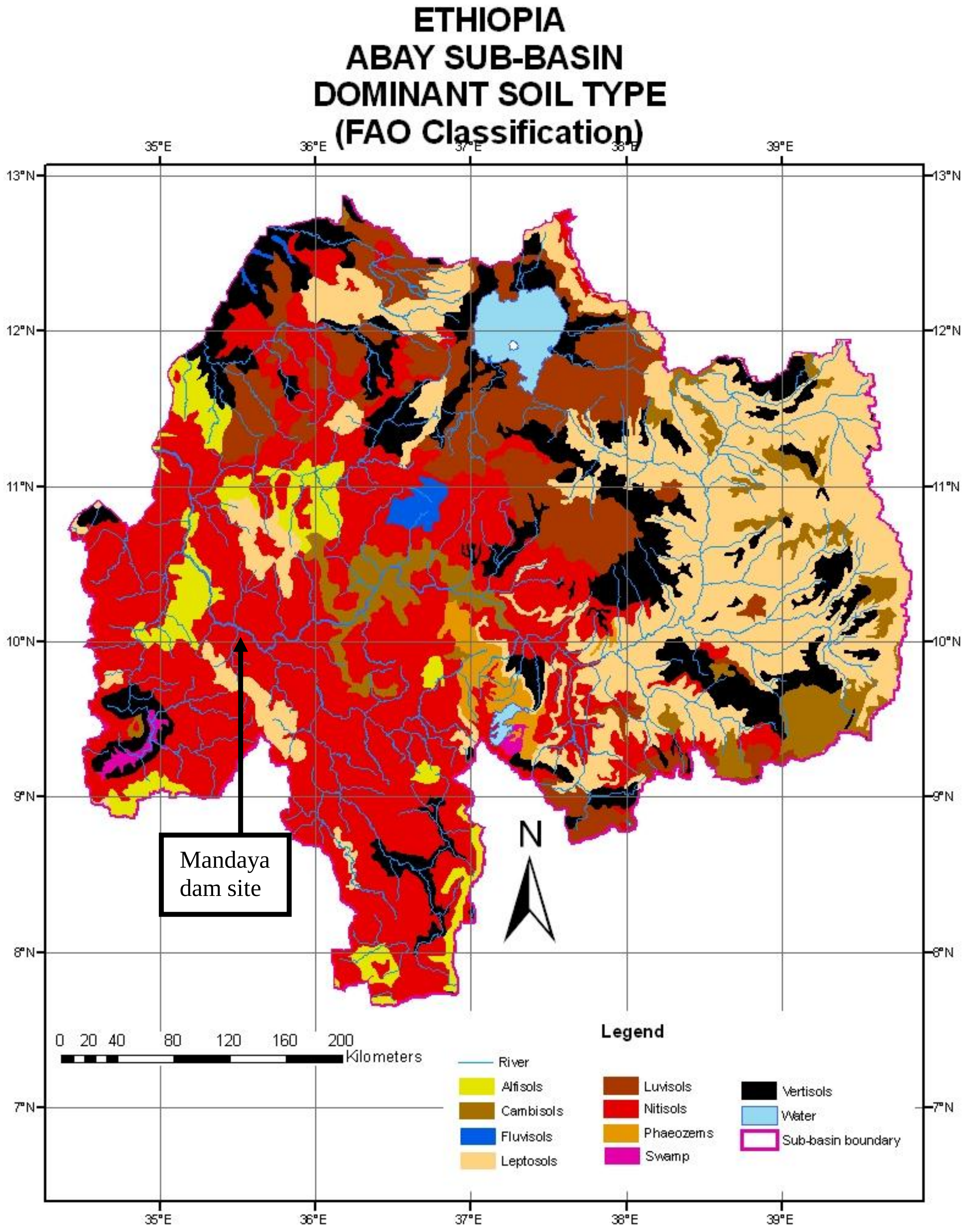
High quality sand can be obtained from crushed rock from the basalt quarry, there being no other sources of sand.

For a roller compacted concrete (RCC) dam with a dam volume of 13 billion m^3, very large quantities of cement and pozzuoland materials are required. Cement is expected to be brought into the area from elsewhere. The Koncho/Sirba Abbay marbles have been noted as a possible local source. For pozzuoland materials, a large body of serpentinite occurs 47 km east of the dam site. The rock is soft and therefore easy to quarry and pulverise. All the minerals are under-saturated aluminium silicates with various metallic cations. Such material might be an alternative to pulverised fly ash, and is expected to be investigated in the feasibility stage.

Further descriptions of geological conditions and minerals, with geological mapping, are provided in the pre-feasibility engineering report.

Soils

Soils in the Mandaya area are broadly classified as Nitosols, one of the nine major soil groups covering the Abbay basin (Figure 4.2). The unit comprises Haplic and Rhodic Nitosols and is capable of cultivation but its acidity reduces the availability of nutrients like phosphorus, calcium and magnesium.



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006

Figure 4.2 : Dominant Soil Types in Abbay Basin

4.1.3 Climate and Hydrology

Rainfall

There are no climatological stations in or close to Mandaya dam site and reservoir location. According to mapping, mean annual rainfall at the Mandaya reservoir site may be assessed at between 1,500 and 1,750 mm (Figure 4.3). The rainfall pattern is almost uni-modal. The "*Belg*", or short rainy season, which occurs from mid-February to mid-May in the east of the Abbay basin and elsewhere is not thought to be so distinct in the Mandaya area. Rainfall quantities in the Belg season are low and variable and frequently have no significant impact on tributary rivers of Abbay in the Mandaya area which may remain dry or continue to recede. The "*Kiremt*" or main rainy season lasts from June to September and may extend in the Asosa and Mandaya area into October, as experienced during our surveys in October 2006. Normally, there is very little rainfall between November and March/April.

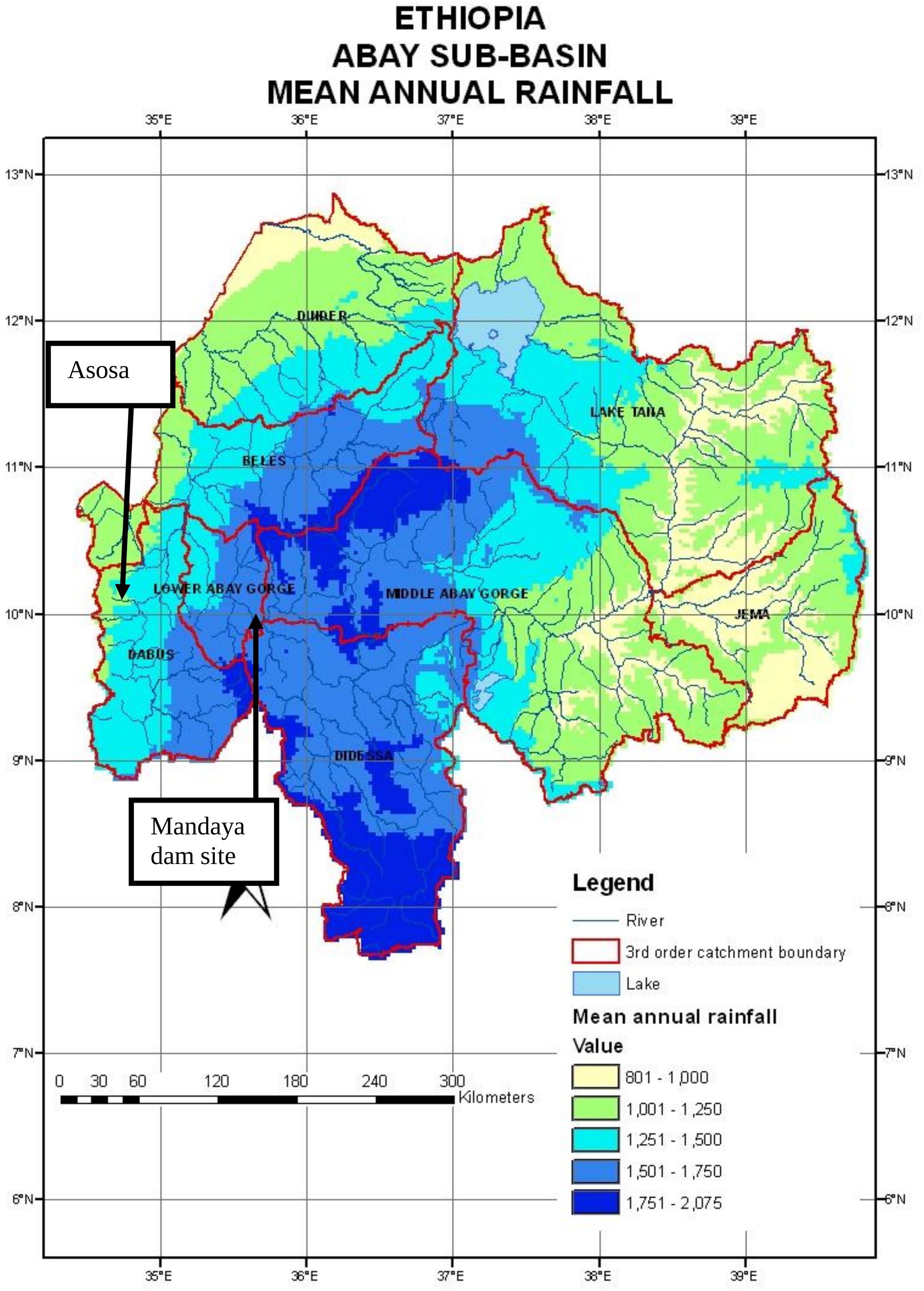
The nearest representative station with climatological records in this region is at Asosa town, located some 110 km west of Mandaya dam site. Climatological statistics for Asosa are published on the National Meteorological Agency's website. Monthly mean rainfall is shown in Table 4.1.

Table 4.1 : Monthly mean rainfall at Asosa

Rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
mm	<1	4	23	60	134	194	234	237	194	132	21	2	1,235
Season	Dry	Dry	Dry	Wet2	Wet2	Wet2	Wet2	Wet2	Wet2	Dry	Dry	Dry	

Note: Wet 2 is main rainy season (Wet1 is small rainy season and is not designated at Asosa)

Source: National Meteorological Agency's website.



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006.

Figure 4.3 : Mean Annual Rainfall in Abbay basin

Temperature

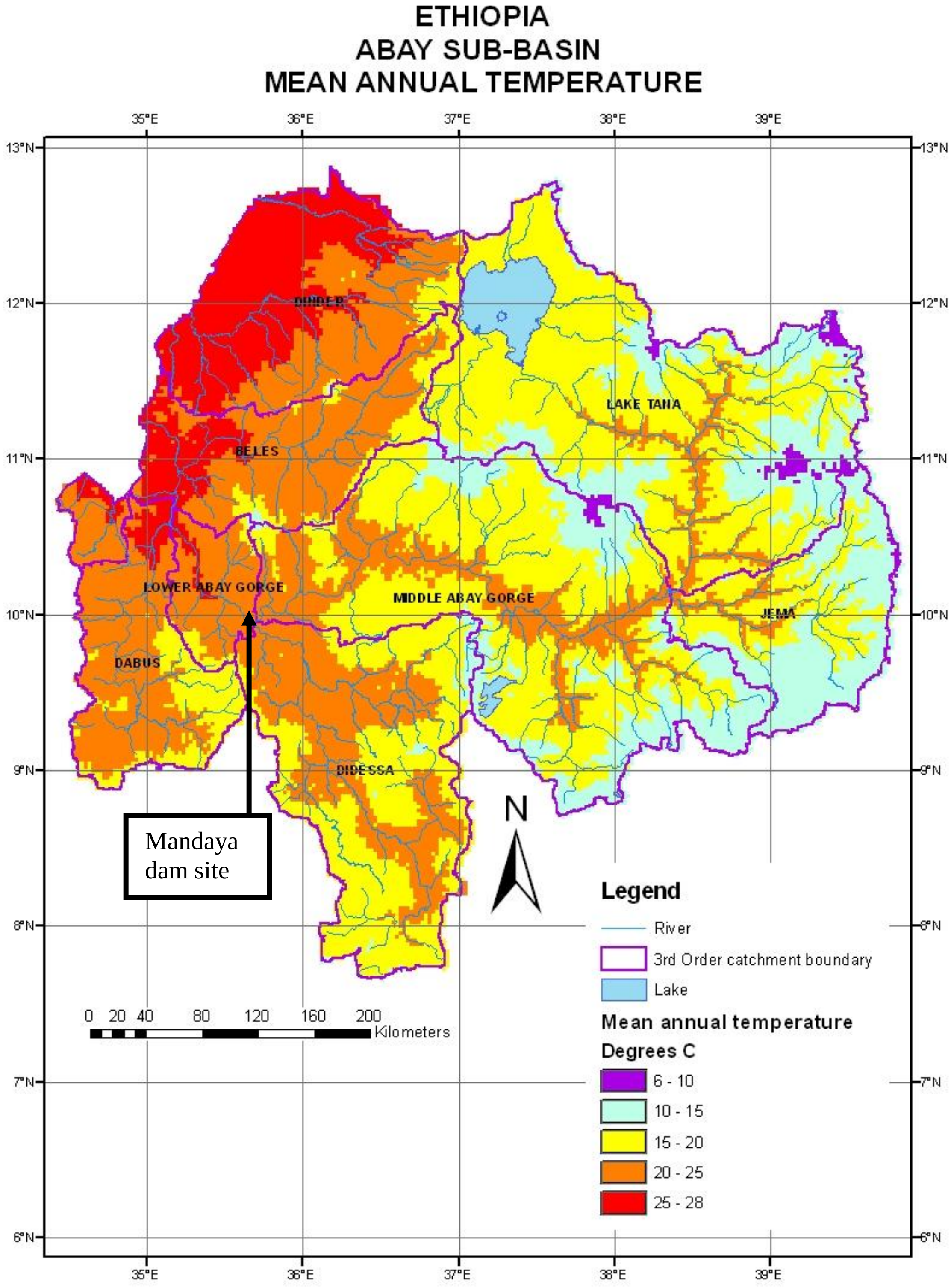
Available regional mapping indicates that Mandaya dam site has a mean annual temperature between 20 and 25°C (Figure 4.4). Micro-climate conditions in the Mandaya gorge may elevate temperatures compared to regional mapping.

In the days around the spring equinox in March 2007, when geological and environmental field surveys were conducted near Boka, daytime temperatures were observed at Boka mission and along the Abbay river. They typically ranged between 30 and 40°C in the shade, sometimes greatly exceeding 40°C. This is noteworthy with regard to ecology and livelihoods, and to future field surveys and civil engineering works in the area. Temperature records for Asosa town (Table 4.2), at an elevation of 1,540 masl, somewhat higher than Boka (600 masl) show that March and April are the hottest months in the region, supporting the high temperatures experienced at Boka and Mandaya in March 2007.

Table 4.2 : Temperatures at Asosa

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean maximum °C	30.5	31.8	32.5	31.7	28.5	25.4	24.6	24.6	25.5	26.4	28.1	29.1	28.2
Mean minimum °C	14.2	15.5	16.5	16.3	15.8	15.3	14.7	14.6	14.7	14.8	14.9	14.3	15.1
Mean °C	22.3	23.6	24.5	24.0	22.1	20.3	19.6	19.6	20.1	20.6	21.5	21.7	21.6
Extreme maximum °C	37.2	36.6	36.8	38.5	38.0	32.5	30.5	29.4	29.5	35.5	35.6	33.0	38.5
Extreme Minimum °C	8.1	8.2	9.0	5.0	6.0	10.0	9.0	8.0	7.0	7.5	9.0	6.7	5.0

Source: National Meteorological Agency's website.



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006.

Figure 4.4 : Mean Annual Temperature in Abbay Basin

Evaporation

Estimates of potential evaporation have been adjusted for estimated rainfall in the RAPSO model to give estimates of average net open water evaporation for Mandaya. These are shown in Table 4.3.

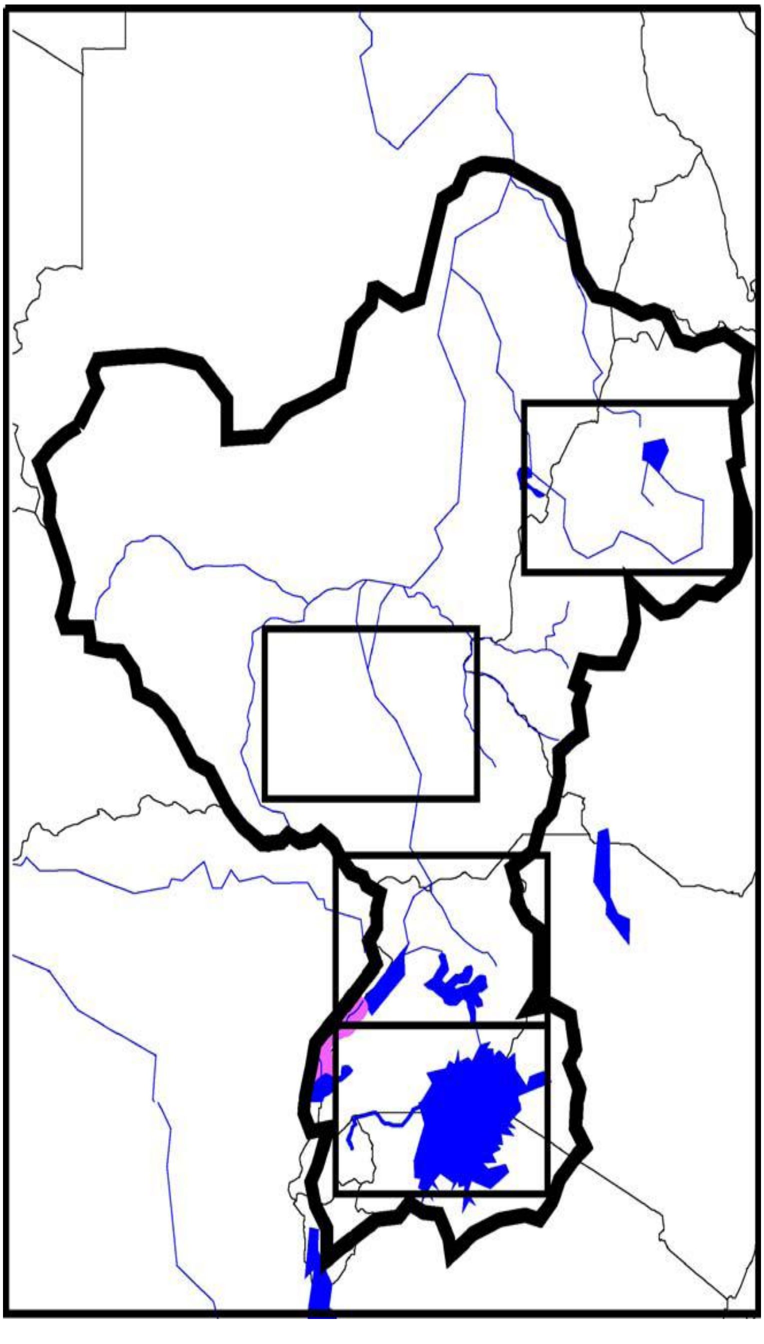
Table 4.3 : Monthly mean net evaporation rates at Mandaya reservoir

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
193	184	147	136	105	-21	-219	-150	17	118	148	180	838

Source: This study, reservoir simulation modeling, pre-feasibility engineering report.

Climate Change

A number of climate and climate change studies of the Nile basin upstream of Aswan High Dam have been conducted. Conway (2005) concludes from a review of many of these that there is high confidence that temperatures will rise, leading to greater losses to evaporation. However, there is much less certainty about future rainfall because of the low convergence in climate model rainfall projections in the key headwater regions of the Nile. He states, for example, that Hulme et al (2001) found large inter-model differences in the detail of rainfall changes over Ethiopia using results from seven recent climate model experiments. Inter-model disparities in future rainfall change over much of the basin are also presented in reports of the Intergovernmental Panel on Climate Change (IPCC, 2001). When rainfall changes are considered for four key regions in the Nile basin for summer (June to August) and winter (December to February) from nine recent climate model experiments using IPCC's special report on emissions scenarios (outlined in Hulme et al, 2003), the Blue Nile region shows large divergence in rainfall changes in summer which is the crucial monsoon rainfall season. In the White Nile system (Lakes Victoria and Kyoga and the Sudd), winter shows inter-model convergence towards a small to large increase in rainfall but there is divergence in summer (Figure 4.5). This large divergence in model results for the Abbay/Blue Nile basin means that there is currently no confident basis for concluding annual rainfalls will be generally higher or lower.



Boxes show four regions used to calculate area averages of temperature and rainfall projections from climate models. Blue Nile region; Sudd wetlands in Southern Sudan; Lake Kyoga central Uganda; Lake Victoria, Kenya, Tanzania and Uganda.

Source: After Conway (2005)

Figure 4.5 : Climate change model areas: Nile basin upstream of Egypt and the Aswan High Dam reservoir

River flow records

There is no gauging station at or close to Mandaya dam site. A record has therefore to be derived by other means.

The Mandaya site is located some 300 km downstream of the gauging station at Kessie bridge and approximately some 180/200 km upstream of the Border gauging station in Ethiopia and the El Deim gauging station in Sudan. No long-term time series data is available for the majority of the intervening catchments. Accordingly, the time series for the Mandaya site has been derived by the "catchment area method" using data for the Abbay at Kessie and the Blue Nile at El Deim. Details are given in the pre-feasibility engineering report.

A summary of catchment areas and flows is given in Table 4.4. Flows in the right hand column are reduced by 77 m^3/s for the Beles hydropower project, now under construction. The Beles project diverts water from Lake Tana (away from the Blue Nile Gorge and Karadobi and Mandaya dam sites) and returns it to the Abbay river via the lower reaches of the Beles river between Mandaya and Border dam sites.

Table 4.4 : Summary of Adopted Flow Series for Project Sites

Site	Catchment Area (km^2)	Mean Annual Flow (Natural) (m^3/s)	Mean Annual Flow (with Beles Diversion) (m^3/s)
Kessie gauging station	65,784	517	440
Karadobi dam site	82,300	649	572
Mandaya dam site	128,729	1091	1014
Border dam site	176,918	1547	1547
El Deim gauging station		1547	1547

The flow series derived for Mandaya is given in Table 4.5. This has a mean annual flow of 1,014 m^3/s, allowing for the Beles diversion. This is equivalent to approximately 32 billion m^3 per year. This record is considered satisfactory for a pre-feasibility study. Installation and calibration of a river gauging station at Mandaya will be required during a feasibility study.

The incremental flow between Mandaya and the Border dam sites is from a large catchment area (48,189 km^2) drained principally by the Dabus and Beles rivers, and by numerous smaller rivers. The mean annual incremental flow, including the returned Beles diversion, is established as 533 m^3/s.

Table 4.5 : Abbay Flows at Mandaya

Abay : **Flow at Mandaya**
Units: **m3/s**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
1954	160.3	116.5	92.2	74.4	76.5	327.4	2541.7	5118.9	3710.5	1768.6	601.7	322.0	1252.5
1955	224.5	145.4	91.7	131.9	162.9	318.4	2086.4	4564.4	3569.9	1691.0	595.0	317.1	1166.6
1956	183.2	125.0	83.9	135.0	93.9	417.5	1893.9	4156.9	2679.9	2544.1	817.2	357.0	1133.4
1957	222.5	152.5	367.9	330.2	135.2	349.9	1386.0	4435.8	2322.6	727.2	360.8	187.6	921.9
1958	133.8	112.6	73.5	90.8	91.1	373.6	2177.5	5006.9	3116.9	1840.2	673.0	325.3	1177.8
1959	216.0	147.6	92.7	74.1	128.8	219.5	1653.5	4580.6	3871.4	1871.6	772.3	393.6	1176.2
1960	249.4	151.1	106.6	76.6	126.8	253.8	2132.8	4610.4	3150.6	1351.5	470.3	245.7	1085.7
1961	171.0	127.7	98.9	144.2	98.4	286.9	2471.0	4545.3	3801.9	2237.0	761.0	498.1	1279.7
1962	234.1	136.1	94.0	57.7	126.1	336.1	1315.7	3960.5	3171.5	1672.3	477.1	273.3	994.6
1963	184.4	127.2	113.1	119.0	307.4	321.2	1674.4	4765.9	2906.5	986.0	569.8	446.1	1051.6
1964	195.8	130.1	51.9	94.8	98.2	356.2	2950.0	4934.2	3613.5	2057.5	761.5	418.6	1315.9
1965	245.9	146.3	99.3	146.2	74.2	233.5	1090.1	3733.5	1992.9	1381.8	618.1	330.0	847.7
1966	182.4	142.1	105.7	95.4	116.9	366.2	1394.5	3644.3	2736.9	772.0	450.3	261.7	860.9
1967	152.4	101.6	102.9	124.7	178.2	273.3	1922.4	4269.1	3068.9	1993.0	657.6	396.7	1112.4
1968	185.2	129.9	82.6	92.3	90.8	387.4	2352.7	3998.3	2281.0	1184.8	401.2	230.0	959.9
1969	150.2	128.4	271.1	97.3	166.7	366.2	1978.0	5140.2	2842.7	852.8	355.2	195.8	1054.3
1970	136.0	112.8	115.0	90.8	74.2	211.8	1609.0	4673.0	2979.6	1329.7	457.6	208.0	1007.8
1971	144.9	106.8	73.3	67.3	109.1	380.7	1762.0	4568.7	2601.6	1140.9	519.0	230.0	983.4
1972	155.2	112.1	77.4	105.4	118.0	270.1	1303.9	2933.3	1438.9	644.3	354.7	189.4	647.3
1973	120.3	68.1	51.3	56.8	153.9	349.7	1486.1	4716.9	2706.3	1242.0	470.9	229.7	979.2
1974	156.6	106.2	89.5	75.4	182.8	422.7	2512.9	4304.4	2665.8	1078.6	426.3	241.2	1030.8
1975	133.5	123.8	80.0	67.0	81.5	339.7	2029.4	4807.3	4294.0	1524.3	568.3	331.9	1205.9
1976	219.3	128.4	118.0	98.5	154.7	302.2	1461.6	4151.3	2398.5	680.9	484.8	247.9	877.1
1977	146.4	123.7	102.1	76.8	107.1	338.0	2399.1	4097.2	3026.4	1229.2	837.9	276.6	1071.0
1978	162.6	107.1	78.5	70.2	106.2	306.2	2001.4	3603.2	2594.5	1540.9	483.0	251.2	949.8
1979	175.2	135.6	77.0	69.7	163.7	342.1	1456.3	3523.7	1934.6	846.9	359.8	186.7	778.9
1980	120.3	91.5	73.2	97.2	107.5	273.1	1742.1	4074.6	2682.9	1053.4	411.4	217.6	919.3
1981	136.2	149.0	280.4	128.7	132.5	218.6	2027.9	3894.9	2810.8	1040.3	376.6	194.2	956.5
1982	146.2	108.0	91.8	82.9	97.6	220.7	1012.0	3358.0	1853.5	1030.4	369.4	185.2	718.8
1983	117.4	90.3	76.4	95.9	153.7	264.3	955.5	4037.5	2389.2	1112.5	433.9	208.1	834.3
1984	127.1	84.8	59.8	52.3	90.6	432.1	1573.7	2774.5	1597.7	540.4	254.8	148.3	649.9
1985	89.1	50.7	47.3	93.1	173.4	292.6	1500.8	4154.0	3180.4	944.8	363.7	196.6	930.4
1986	126.7	100.5	91.9	120.8	347.6	292.9	2011.5	3261.2	2330.6	819.5	301.3	155.4	836.7
1987	101.3	79.7	129.7	121.7	219.0	535.5	1015.6	3086.5	1455.7	792.7	387.0	188.9	681.6
1988	110.3	94.6	85.3	67.3	69.5	388.5	3075.1	5594.3	3593.5	2073.7	733.2	420.1	1371.0
1989	191.2	129.5	112.7	148.8	108.2	242.1	1522.8	3420.7	2445.6	914.8	329.4	218.6	821.3
1990	170.6	120.7	91.2	87.8	77.1	161.8	1233.9	3568.6	2359.5	970.3	333.6	176.6	785.2
1991	112.9	83.9	77.2	108.8	154.4	322.8	2352.0	4097.9	2715.2	945.3	399.3	226.6	974.5
1992	140.3	118.1	85.9	75.3	138.7	274.8	1095.2	3586.4	2578.7	1522.0	669.7	335.4	891.2
1993	190.7	135.5	83.4	263.1	314.6	621.2	2291.7	3948.1	3120.5	1547.5	656.5	307.4	1131.0
1994	180.1	122.9	84.4	70.1	163.5	423.8	2694.2	5522.3	3471.3	1062.8	469.1	196.7	1215.1
1995	132.4	92.5	87.5	134.9	149.7	314.3	1670.3	3924.8	2406.2	817.7	340.5	204.1	863.2
1996	144.4	83.7	120.3	163.4	396.4	1001.6	3223.6	5081.3	2845.2	1215.0	482.3	302.3	1266.0
1997	214.6	107.8	173.9	138.6	252.1	663.0	2326.7	3547.8	1588.1	998.9	887.5	369.8	947.2
1998	210.8	167.9	125.3	127.3	179.3	382.5	2695.0	6172.1	3628.6	2310.5	748.3	354.2	1437.7
1999	216.9	128.2	90.0	61.0	160.5	412.8	2855.1	4906.5	2967.8	2336.6	783.5	382.1	1286.9
2000	210.8	165.7	62.6	126.4	177.2	446.2	2082.0	4966.9	2628.9	1791.4	863.0	373.8	1167.6
2001	187.8	98.8	188.2	187.8	220.4	594.5	3338.4	5143.7	2900.8	1105.9	491.4	258.6	1237.6
2002	331.2	91.9	176.3	168.3	126.6	428.8	1674.8	3646.2	1990.4	747.7	340.5	183.6	832.6
2003	133.5	103.2	142.9	129.9	93.9	399.7	2455.5	4180.3	2629.3	1029.0	356.2	178.4	994.4
Mean	169.7	116.9	108.6	110.3	148.5	361.2	1949.4	4255.9	2753.0	1298.2	521.7	271.5	1013.5
Max	331.2	167.9	367.9	330.2	396.4	1001.6	3338.4	6172.1	4294.0	2544.1	887.5	498.1	
Min	89.1	50.7	47.3	52.3	69.5	161.8	955.5	2774.5	1438.9	540.4	254.8	148.3	

Groundwater

There has been no systematic survey of springs and groundwater in the Mandaya project area and so documented quantitative information about groundwater availability has not been found. Generally, the geology of the area is not conducive to having major aquifers.

4.1.4 Water Quality

Historical records of water quality at the Mandaya dam site are not available. As part of the fieldwork for this study, single water quality samples were obtained from Abbay river at the Bure-Nekemte bridge at the upper end of the potential Mandaya reservoir and at the proposed Border dam site downstream. A sample was also taken of Beles river at Beles river bridge (23 km from Mankush). Physical and chemical parameters are shown in Table 4.6 along with a sample for Abbay at Karadobi for comparison.

These records are snapshots only. They necessarily cannot begin to describe water quality in flood conditions in July to September when most water is delivered. Having noted this, no pollution or nutrient level is out of the expected range.

Water quality sampling at Mandaya is required in future to cover all seasons. Laboratory analysis of future water samples will be required to cover a much broader range of parameters. The results of any prescribed reservoir water quality modelling will also have to be considered in the light of phyto- and zooplankton, benthic fauna, macrophytes, fish and other aquatic life (Section 4.2.6).

Table 4.6 : Water quality of Abbay and Beles rivers

Parameter	Abbay at Alamia near Border Dam site	Abbay at Bure-Nekemte Bridge	Beles River near confluence with Abbay	Abbay at Karadobi Dam site
Date of Sampling	26/1/07	26/1/07	25/1/07	15/2/05
Turbidity (NTU)	18	110	Trace	22
Total Solids 105^0C (mg/l)	145	302	206	160
Total Dissolved Solids 105^0C (mg/l)	120	146	204	160
Electrical Conductivity (µS/cm)	180	236	307	226
pH	7.87	7.72	8.23	8.26
Sodium (mg/l Na)	6.8	5.8	8.8	13
Potassium (mg/l K)	1.9	2	1.8	2.7
Total Hardness (mg/l $CaCO_3$)	92	121.9	167.9	102.2
Calcium (mg/l Ca)	29.12	37.31	47.32	28.5
Magnesium (mg/l Mg)	4.4	6.6	11.55	7.6
Total Iron (mg/l Fe)	0.35	0.31	0.04	
Manganese (mg/l Mn)	0.1	0.13	0.02	
Fluoride (mg/l F)	0.73	0.88	Trace	0.21
Chloride (mg/l Cl)	2.88	3.84	1.92	3
Nitrite (mg/l NO_2)	0.02	0.055	Trace	0.044
Nitrate (mg/l NO_3)	3.42	4.17	0.3	0.044
Alkalinity (mg/l $CaCO_3$)	81.6	96	163.2	
Carbonate (mg/l CO_3)	Trace	Trace	4.8	
Bicarbonate (mg/l HCO_3)	99.55	117.12	189.34	96.6
Sulphate (mg/l SO_4)	13.08	14.6	6.3	24.7
Phosphate (mg/l PO_4)	0.21	0.17	0.13	0.136

Source: This study. Analysis by Water Works Design & Supervision Enterprise Laboratory, Addis Ababa. Karadobi data from Karadobi Pre-feasibility Report, Volume 5, Table 5-1 (2006).

4.1.5 Sediment Transport and Watershed Management

There is no gauging station and therefore no record of suspended sediment transport at or near to Mandaya dam site. A record has therefore to be derived by other means. This has been done in the pre-feasibility engineering study. In summary, suspended sediment records are available on the main river for Kessie gauging station and at Border and El Deim in Sudan. They are also available for other stations, as shown later. However, the available data is not sufficient to make a reliable estimate of the sediment transport at Mandaya dam site.

The pre-feasibility engineering study has estimated a mean annual total sediment load of 285 million tons (suspended and bedload) at Mandaya. This is based on a) a suspended sediment rating curve derived for Kessie gauging station giving 220 million tons, and b) and 65 million tons of sediment from the incremental catchment area between Kessie and Mandaya.

The estimate for Kessie is based on a small sample of sediment concentration measurements obtained in year 2004; the number of samples (7) is insufficient for a reliable estimate. Many more sample are needed covering several rainy seasons, not one season when special circumstances may have influenced results. Acknowledging this weakness, the sampling in 2004 produced the only set of data available since 1995 and it may be representative of current land use conditions which are believed to be deteriorating as greater pressure is put on using resources of the Kessie catchment area by the increasing population. The yield is equivalent to 2,791 tons/km^2/year which, if confirmed, is an extraordinarily high yield. Conditions of the catchment are summarised later.

The estimate for the incremental catchment area between Kessie and Mandaya is based on a yield of 900 tons/km^2/year. It is based on the observation that catchment land cover and land use conditions are generally better in this downstream area and the assumption that sediment yield in this area may be represented by sediment yield at Kessie measured in 1960-61. This is no more than a working hypothesis in the absence of sufficient data (Table 4.7).

Table 4.7 : Estimated Sediment Discharge at Mandaya

Location	Catchment Area (km^2)	Specific Suspended Sediment Discharge (t/km^2/yr)	Average Sediment Load* (million tonnes / yr)
Kessie*	68,074	2,791	220
Incremental catchment area Kessie to Mandaya	60,655	900	65
Mandaya	128,729		285

*based on data for Year 2004 including bedload

The estimate for Mandaya also needs to be seen in the context of sediment gauging downstream at Border and El Deim gauging stations and in terms of watershed management proposals.

Records at Border and El Deim

Consultations with Ministry of Water Resources hydrometric and hydrology staff in Addis Ababa in March 2007 revealed that there has been no program of sediment monitoring at the Border gauging station during the last 30 years. This is in part because of security reasons but also because the cableway and cable car, installed in or close to 1963, is considered dangerous to use.

Consultations with Ministry of Irrigation and Water Resources in Khartoum in March 2007 revealed that there has been no comprehensive program of sediment monitoring at El Deim gauging station since about 1980. Similar reasons are quoted as for the Ethiopian station a short distance upstream: security issues, and cableway operational problems. (When the El Deim station was working well, samples were typically taken in five verticals at five depths, giving 25 samples to estimate the sediment concentration). A commendable effort has been made to collect “hand grab” bank-side samples in subsequent years in order to at least obtain some kind of record. However, experience elsewhere shows that there is normally no clear relationship between sediment concentrations in bank-side samples and mean concentrations resulting from comprehensive monitoring. It is necessary therefore to be very wary of estimates of Abbay/Blue Nile sediment transport quoted for the Ethiopian/Sudan border at El Deim.

From the mapping and analytical work carried out for the Abbay Master Plan (1999) and more recently by ENTRO for the watershed management report/CRA reports, it is clear that the source areas of the bulk of Abbay’s sediment loads are in the eastern part of the catchment area.

Overview of watershed management issues – CRA Country Paper

Our aerial survey flight and overland surveys in October 2006 confirmed the stark contrast between the densely cultivated east, with deeply incised tributaries and gullies, and the generally tree-covered west. During the aerial survey, it was noted that the Abbay river was reddy brown in colour throughout its length from near Kessie Bridge, through the Mandaya reach to Border. The only clear water seen was in a few small tributaries downstream of the Abbay/Didessa confluence.

Our foot surveys of the Mandaya and Border dam sites and potential reservoir areas between January and March 2007 confirmed that soil erosion features are few, generally confirming that these lower areas are in the “low sediment” hazard zone described in the Abbay Master Plan Study. This is due to very low population density coupled with limited areas of traditional cropping and livestock production, and generally good to very good vegetation cover.

In the CRA Country Paper for Ethiopia, a comprehensive synopsis of the watershed management problems in the Abbay basin is given. It is noted that the highland plateaus have been deeply dissected by the Abbay and tributaries providing severe constraints to road communications and access to markets. Agriculture expansion on to steep slopes and the consequent loss of vegetation have accelerated geological rates of soil erosion. Steep slopes and lack of vegetative cover result in relatively high rates of sediment delivery to the main rivers. Millennia of cultivation coupled with breaches in soil nutrient cycling caused by residue and dung use as fuel, grain removal and soil erosion have led to low levels of crop and pasture productivity.

Detrimental government policies in the past have left a legacy of tenure insecurity and poverty with severe constraints on farmers' willingness and ability to invest in sustainable land management. Past large-scale programmes of soil conservation and afforestation were top-down and alienated the rural population. High rainfall in the Highlands can cause problems with physical soil conservation structures of poor drainage and of structure breaches and severe erosion.

The western Lowlands (west and downstream of Mandaya), sparsely populated because of the prevalence human and livestock diseases, provides potential for agricultural expansion.

The CRA Country Paper assesses the extent of soil degradation in terms of sheet and rill erosion, gully erosion and mass movements (Figure 4.6).

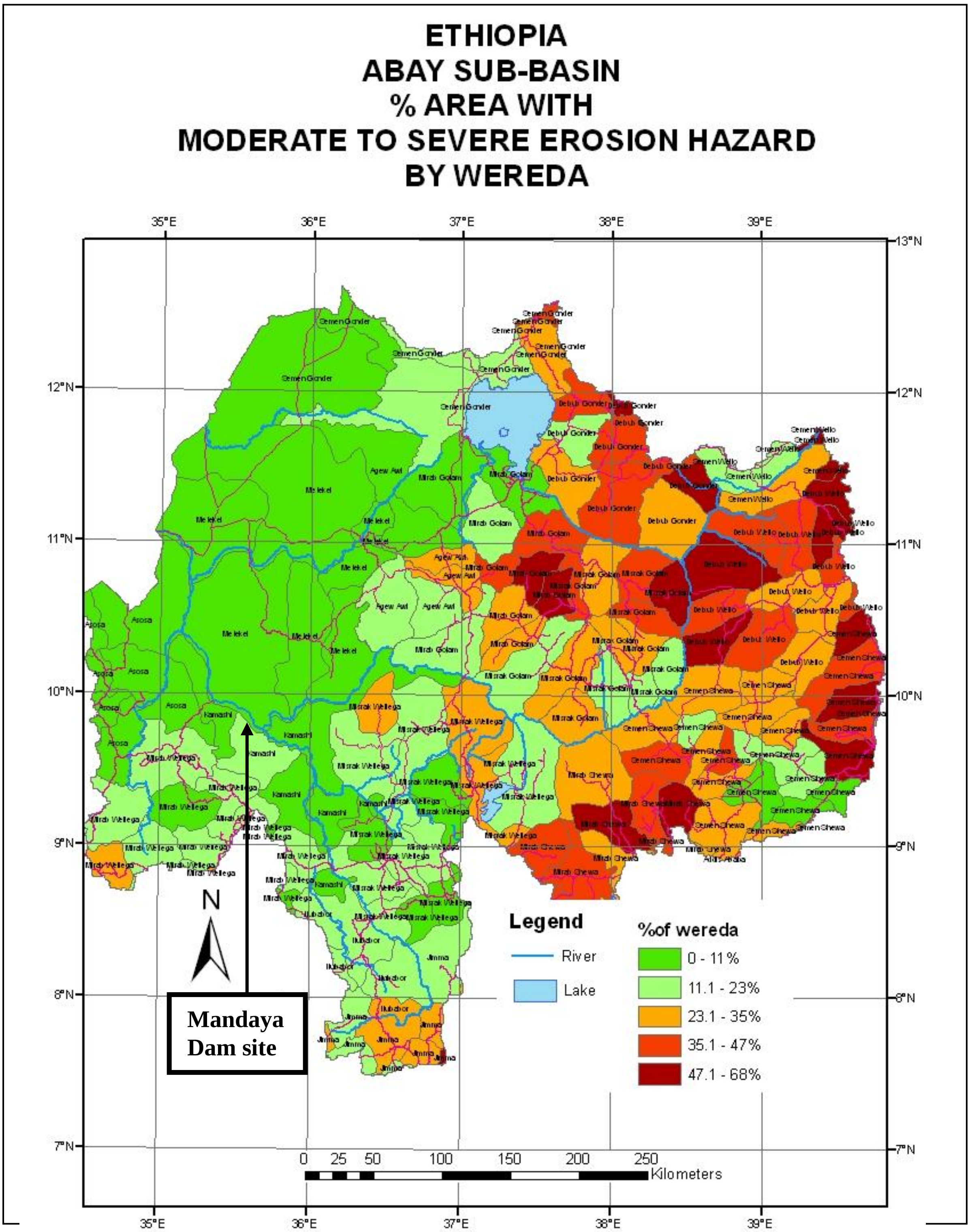


Figure 4.6: Abbay basin - moderate to severe erosion hazard by woreda

With this background to sedimentation, the Country Paper goes on to state "Infrequent, unsystematic and incomplete suspended sediment data for the El Deim gauging station just across the border in Sudan is available. This has been analysed by Group 1 of the NBCBN/River Morphology Research Cluster. They estimated that the long-term mean suspended sediment at El Diem to be 123 million tons. They estimated bed load to be 15% giving a total mean annual sediment inflow of 140 million tons". These figures give a mean annual suspended sediment yield for the Abbay basin of approximately 700t/km^2/yr, and approximately 800t/km^2/yr for total load (including bed load).

The original NBCBN/River Morphology Research Cluster report (2005) on "Assessment of the current state of the Nile basin reservoir sedimentation problems" describes the sampling data and procedures on which these estimates are based. The sampling procedures are not mentioned in the CRA papers. The suspended sediment was "measured by bottle sampling taken once a day from the channel bank" at El Deim gauging station. Reading from a graph in the Research Cluster report, approximately 125 samples were taken in the months of July, August, September and October in 10 individual years spanning from July 1970 to August 1994. The plotted data reveal hysteresis looping with July and early August data normally giving distinctly greater sediment loads than the same flows on flood recession. Separate ratings were developed for rising and falling flood stages. Flow duration curves for 30-years record at El Deim gauging station (1966 – 1995) were developed for each 10-day period of the flood months (July to September) and sediment ratings applied to these (Table 4.8).

Table 4.8: Mean Suspended Sediment Load at El Deim

Month	**July**			**August**			**September**			**All**
Period	I	II	III	I	II	III	I	II	III	
M tons	7	10	19	22	26	27	5	4	3	123

Source: NBCBN/River Morphology Research Cluster report (2005)

This work is the basis for the estimate of 123 million tons mean annual suspended sediment load and 140 million tons mean annual total sediment inflow at Roseires. The following cautionary points may be noted:

- Sediment samples at El Deim were taken at five points in five verticals across the river from a cable car during the station's early history (1960s). The samples giving rise to the estimate of 140 million tons (July 1970 to August 1994) are stated to be taken at the water's edge. The relationship between concentrations based on comprehensive sampling (as in the 1960s) and at the riverbank is unknown.

- El Deim sediment ratings include data from as early as 1970, and are therefore weighted in part to conditions more than 35 years ago; similarly, the most recent samples used to establish ratings (in 1994), some 13 years ago, may be unrepresentative of current land use conditions.

- The Abbay Master Plan report estimated sediment transport annual yield of 168 million tons at Border dam site, using a rating curve for Border gauging station based on sediment sampling in 1961 only – more than 45 years ago (See below).

- All of the above points suggest that the estimate of 140 million tons total mean annual sediment load at El Deim is likely to seriously underestimate sediment transport at Border dam site.

The Ethiopian Country Paper goes on to state that "the Tekezi Medium Hydro Study (1998) quoted a much higher figure of 273 million tons per annum as the mean annual suspended sediment load for Roseires".

The Country Paper presents summary data for 15 selected stations in the Abbay basin (Table 4.9), giving the source as Abbay Basin Master Plan Study. From our understanding of there being no comprehensive sediment monitoring at Border during at least the last 27 years, we are not aware of any sediment rating curve for Border which represents current land use conditions. We have therefore to conclude that the sediment load quoted (140 million tons/year) is based on a flow record period from 1980 to 1991 and not on a sediment rating curve developed from comprehensive sampling during these years.

Table 4.9: Suspended sediment loads in Abbay basin

Station	Length of record	Catchment area (km^2)	Sediment load ('000 tons/yr)	Soil loss in ($t/km^2/yr$)	Mean Annual discharge (m^3/s)
Gilgel Abay, near Merawi	1980-1992	1,664	2,821	1,695	58.17
Gumara, near Bahir Dar	1980-1992	1,394	1,937	1,390	27.18
Megech at Azezo	1980-1992	462	263	569	7.5
Abay at Kessie	1982-1992	65,784	49,404	751	450.5
Muger, near Chancho	1980-1992	489	38	78	9.26
Abay at Bahir Dar	1980-1992	15,321	2,191	143	111.32
Guder at Guder	1980-1992	524	47	90	12.63
Birr, near Jiga	1980-1992	975	2,075	2,129	17.86
Dura, near Metekel	1980-1992	539	386	717	
Angar, near Nekemte	1980-1985	4,674	702	150	62.79
Dabana, near Abasina	1980-1984	2,881	453	157	57.35
Angar, near Gutin	1982-1983, 1986-1992	1,975	176	89	
Beles, near Metekel	1983-1992	3,431	1,563	456	51.38
Abay at Sudan border	1980-1991	172,254	140,000	700	1555.73

Source: After Final Country Report, Ethiopia, Hydrosult *et al*, 2006 (attributed to Abbay Basin Master Plan Study)

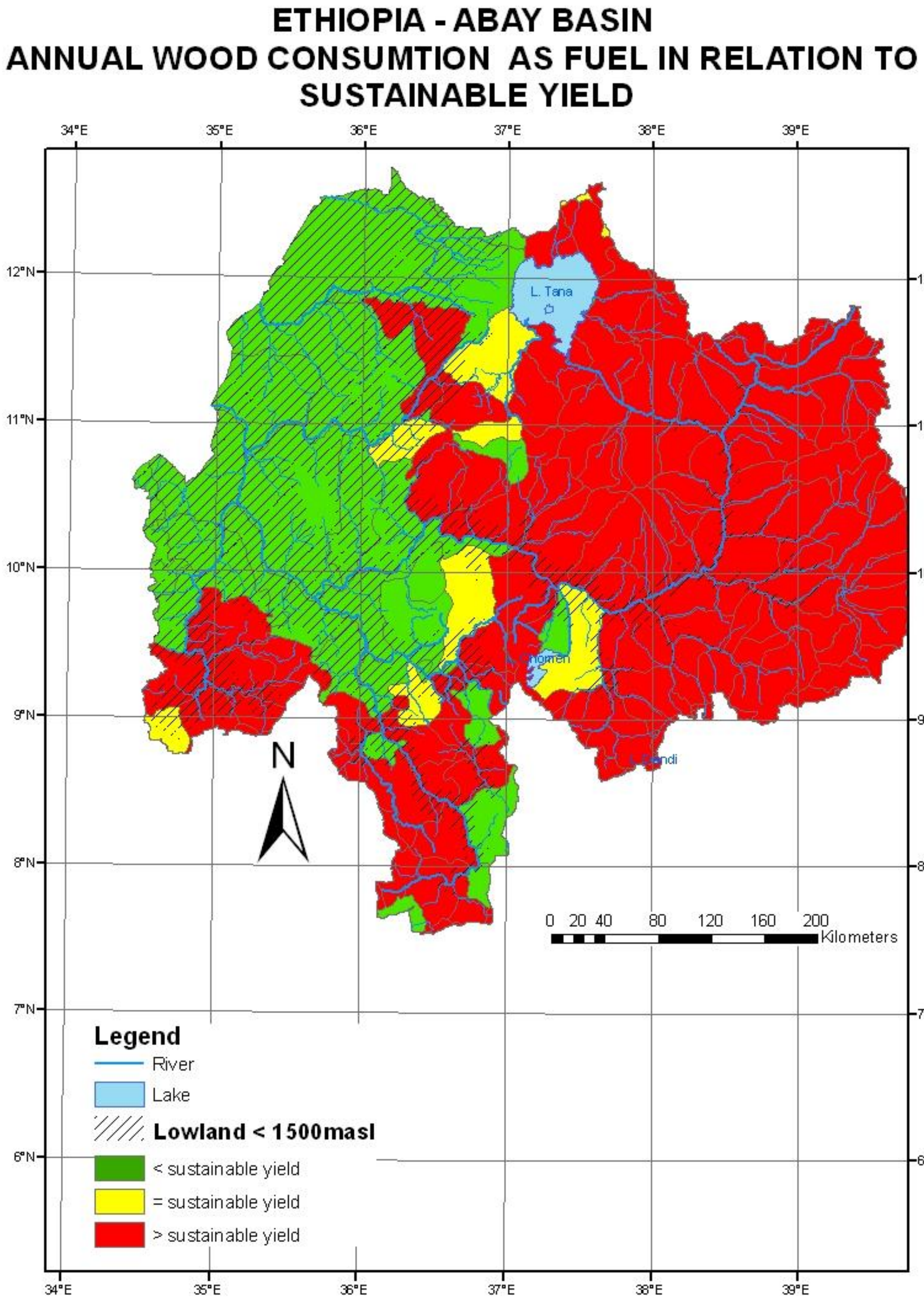
In the Abbay Master Plan report itself, we note that sediment transport is presented for potential dam sites including Mandaya and Border. For Mandaya dam site, the sediment transport annual yield is given as 124 million tons, and for Border 168 million tons. (Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles). The Border estimate appears to be based on sediment samples at Border gauging station obtained in only a seven month period in one year (between March and September 1961), now more than 45 years ago (Phase 2, Data Collection – Site Investigation Survey and Analysis. Section II Sectoral Studies, Volume III – Water Resources, Appendix 6).

The Country Paper goes on to consider sources of accelerated soil nutrient losses (Nitrogen and Phosphorus) from burning of dung and crop residues, removal of crop grain and soil removed due to soil erosion.

The Paper then assesses the extent of deforestation and degradation of vegetation cover in the Abbay basin. It is noted that in the western lowlands, mainly encompassing Benshangul-Gumuz region there remains considerable areas for agricultural expansion where, in the past, settlement and expansion of agriculture has been constrained by the presence of human diseases (particularly malaria) and cattle diseases (particularly trypanosomiasis). Past large-scale resettlement schemes are reviewed (Pawe in the Beles Valley, Anger Valley, a tributary of the Didessa) including in the late 1970's the large-scale mechanized farm of 96,000 ha being cleared and developed in the lower Didessa and Anger Valleys. It is noted that the latter experienced continued declining yields and following the fall of the Derg it was abandoned, and such was the efficiency of the clearing of the original woodland that even after 10 years it remains grassland with no woody vegetation.

The Country Paper notes that there has been no monitoring of land cover changes in response to new resettlement and agricultural investment programs.

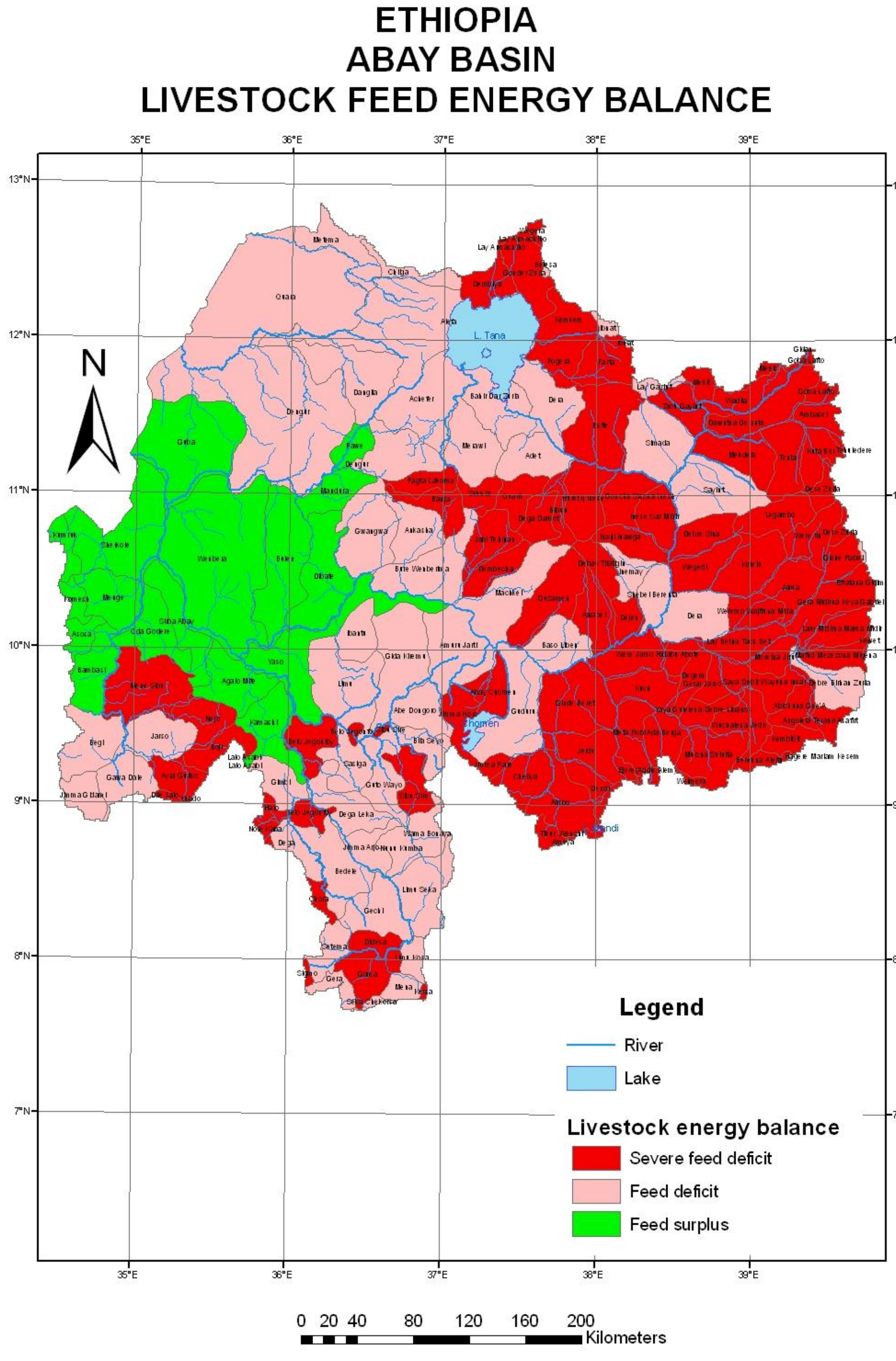
The Country Paper discusses woody biomass, noting that removal of wood in excess of the sustainable yield (after accounting for removal of dead wood and fallen branches, leaves and twigs) leads to declining stocks, which in turn leads to declining yields and so to progressive degradation of woody biomass. The proportion of sustainable annual woody biomass yield consumed as fuel wood by woreda is shown in Figure 4.7, where it can be seen that the pattern of woredas consuming in excess of sustainable yield mirrors that of the woredas with high proportions of their area experiencing moderate to severe soil erosion (Figure 4.6).



Source: Final Country Report, Ethiopia, Hydrosult *et al*, 2006

Figure 4.7: Abbay basin – annual woody biomass consumption

The Country Paper notes that an indicator of overgrazing can be determined by examining the livestock feed energy balance at woreda level. Energy requirements of all livestock are computed using energy requirements for maintenance, draught power and lactation, and balanced against estimates of energy supply from natural pastures and crop residues (Figure 4.8). The main areas of livestock feed deficits are largely coincident with the areas of high soil erosion hazard.



Source: Final Country Report, Ethiopia, Hydrosult *et al*, 2006

Figure 4.8: Abbay Basin - Livestock feed energy balance by woreda

The Country Paper gives examples of reservoir siltation in the Abbay basin. It notes that a reservoir for the water supply of Gondar town was constructed in 1986 where the annual sediment yield in the catchment is estimated at 1,200 tons/km^2. It is reported that by year 2010 the reservoir capacity will be only 50% and water shortages can be expected thereafter. Another report is cited where five of seven dams supported by the Commission for Sustainable Agriculture and Environmental Rehabilitation for Amhara region are seriously affected by siltation.

4.1.6 Summary of estimates of sediment transport and sediment budget

The various estimates of sediment transport at Mandaya dam site, Border dam site and Roseires (taken to be proxies for the same location) from the above reports, and our pre-feasibility engineering reports, are summarised in Table 4.10.

Table 4.10: Estimates of sediment transport at Mandaya, Border, El Deim and Roseires

Estimate of sediment transport Mt/year	Source	Notes
Mandaya 124	Abbay Master Plan, Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles. (February 1998)	Estimate appears to be made on the basis of sediment sampling in a seven month period in one year (March to September 1961), now more than 45 years ago
Mandaya 285	Mandaya pre-feasibility engineering report, this study, 2007	Based on estimate for Kessie based on sampling at Kessie in 2004 only, and yield of 900 t/km^2/year downstream of Kessie. Includes estimate of bed load
Roseires 40	NBCBN/River morphology research cluster (2005)	Annual silt deposit behind Roseires dam in 1965
El Deim 140	NBCBN/River morphology research cluster (2005) and CRA Country Report (September 2006)	Includes estimate of bed load. Based on bank-side bottle sampling, approximately 125 samples in the months of July, August, September and October in 10 individual years spanning from July 1970 to August 1994
Border 168	Abbay Master Plan, Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles. (February 1998)	Assumed to include bed load and thought to based on sediment sampling in 1961 only.
Roseires 273	Tekezi Medium Hydro Study (1998) cited in CRA Country Report (September 2006)	Mean annual suspended sediment load at Roseires
Border 318	Border pre-feasibility engineering report, this study (2007)	Includes estimate of bed load

Source: Compilation in this study, as stated.

These observations on sediment transport estimates at Karadobi, Mandaya and Border are in conflict with the sediment budget presented for the Eastern Nile basin in the Draft CRA report on Distributive Analysis (January 2007). In that draft report, the annual sediment load at Border is given as 140 million tons and the annual sediment load entering Lake Nubia/Nasser as 142 million tons (Table 4.11). The small difference (2 million tons) is accounted for in the budget by incremental sediment inflows from Rahad, Dinder, White Nile and Atbara being more or less balanced by sediment deposition in Blue Nile storage reservoirs, irrigation schemes and the Nile's river bed and alluvial plains on the way to Lake Nubia/Nasser.

With significantly higher estimates of sediment transport at Border for current conditions, the sediment budget would necessarily be disturbed. However, there appears to be no reason why the budget could not be adjusted to reflect greater sediment inflows from the Abbay. It would require greater depositions along the Nile and the possibility of adopting a different density factor for converting surveyed volume of sedimentation (m^3) in Lake Nubia/Nasser to equivalent tons.

Table 4.11: Eastern Nile Basin: Estimated Current Sediment Budget: No Watershed Management Programme and only Existing Dams

LOCATION	NO WSM OR DAMS
SEDIMENT ENTERING KARADOBI	92.00
SEDIMENT RETAINED IN KARADOBI	0.00
SEDIMENT THRU' KARADOBI	**92.00**
SEDIMENT ENTERING ABBAY RIVER BELOW KARADOBI (EXCLUDING BELES)	46.81
SEDIMENT ABOVE BELES-ABBAY CONFLUENCE (M t/yr)	138.81
SEDIMENT ENTERING BELES	1.56
SEDIMENT RETAINED IN BELES RESERVOIR	0.00
SEDIMENT THRU' BELES	1.56
SEDIMENT IN ABBAY AT BORDER	**140.37**
SEDIMENT ENTERING ROSIERES	140.37
SEDIMENT RETAINED IN ROSIERES (%)	15%
SEDIMENT RETAINED IN ROSIERES M t/yr	21.06
SEDIMENT THRU' ROSIERES	119.31
SEDIMENT ENTERING RAHAD + PUMP SCHEMES	119.31
SEDIMENT RETAINED IN RAHAD + PUMP SCHEMES (%)	1.88%
SEDIMENT RETAINED IN RHAD = PUMP SCHEMES PUMP (M t/yr)	2.24
SEDIMENT AFTER RAHAD = PUMP SCHEMES	117.07
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	1.25%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	1.46
SEDIMENT ENTERING SENNER RESERVOIR	115.61
SEDIMENT RETAINED IN SENNER (%)	10%
SEDIMENT RETAINED IN SENNER	11.56
SEDIMENT THRU' SENNER	104.05
SEDIMENT AT GEZIRA/MANAGIL INTAKE	104.05
SEDIMENT RETAINED IN GEZIRA/MANAGIL (%)	7.5%
SEDIMENT RETAINED IN GEZIRA/MANAGIL M t/yr	7.88
SEDIMENT AFTER GEZIRA	96.17
SEDIMENT FROM RAHAD-DINDER	9.19
SEDIMENT BELOW RAHAD-DINDER CONFLUENCE	105.36

LOCATION	NO WSM OR DAMS
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	2.5%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	6.32
BLUE NILE SEDIMENT AT KHARTOUM	99.04
SEDIMENT FROM WHITE NILE (3% OF 142mT/YR)	4.26
SEDIMENT MAIN NILE AT KHARTOUM (Mt/yr)	**103.30**
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	4%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	4.13
SEDIMENT MAIN NILE ABOVE ATBARA	**99.16**
SEDIMENT FROM ATABARA	58.43
SEDIMENT MAIN NILE BELOW ATBARA CONFLUENCE	**157.60**
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	4%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	6.30
SEDIMENT ENTERING MEROE RESERVOIR (M t/yr)	**151.29**
SEDIMENT RETAINED IN MEROE RESERVOIR (%)	0%
SEDIMENT RETAINED IN MEROE RESERVOIR (M t/yr)	0.00
SEDIMENT BELOW MEROE DAM (M t/yr)	151.29
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	6%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	9.08
SEDIMENT ENTERING LAKE NASSER/NUBIA (M t/yr)	**142.22**
SEDIMENT ENTERING LAKE NASSER/NUBIA (M M3/yr)	133.85
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (%)	96%
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (M t/yr)	136.53
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (M m3/yr)	128.50
SEDIMENT THRU' LAKE NASSER	5.69

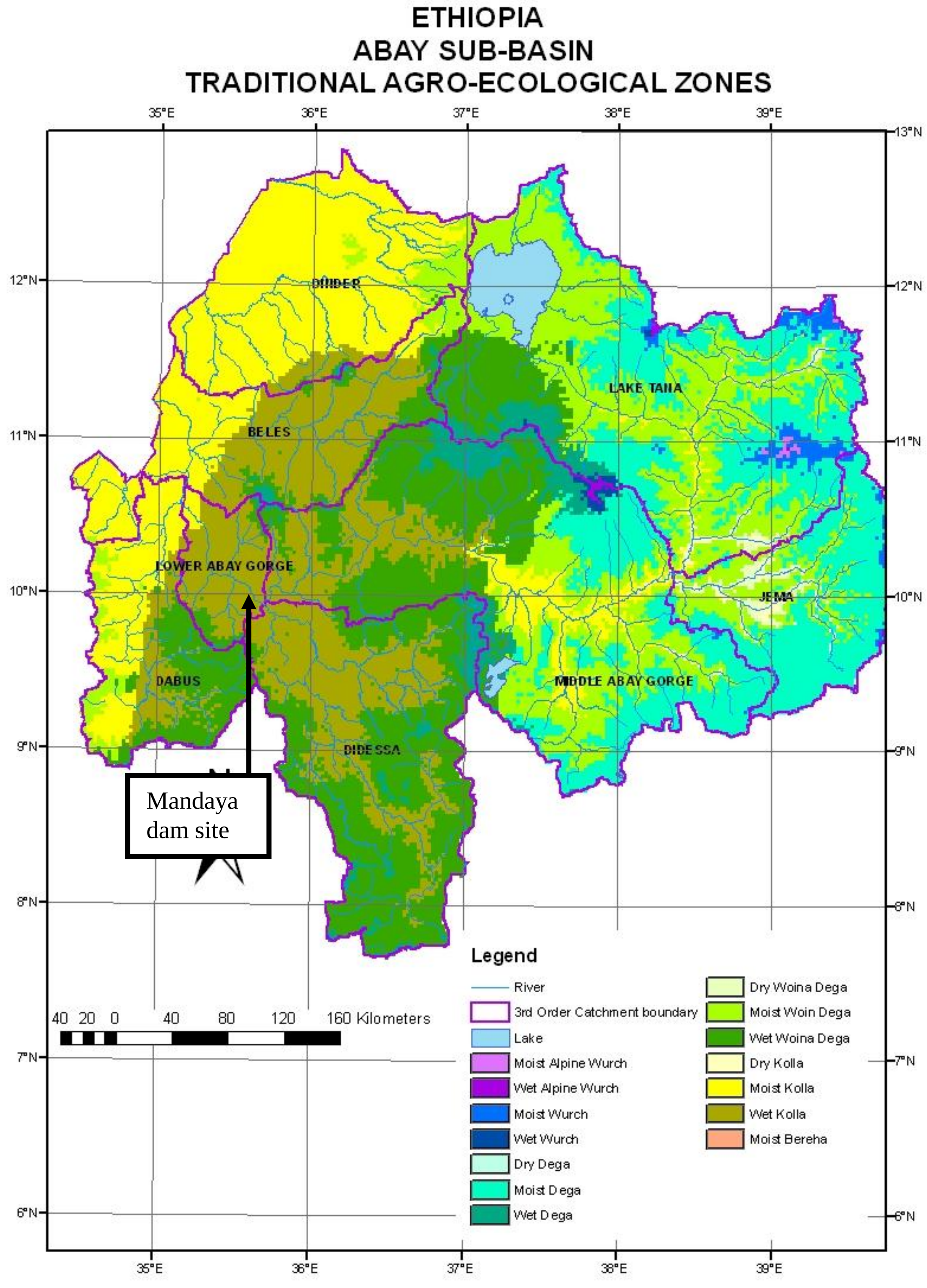
Source: Draft CRA report on Distributive Analysis (January 2007)

The Ethiopian Country Paper states "in the absence of any widespread, consistent and long term monitoring it is difficult to estimate medium or long term trends of erosion or sedimentation". We concur with this statement and elsewhere recommend that a project gauging station is opened at Mandaya before or during a feasibility study and that rehabilitation of the Border river gauging station cableway for systematic and regular sediment sampling is a priority action.

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Agro-ecological zones

The potential Mandaya reservoir area lies within the Wet Kolla agro-ecological zone. This is one of 14 agro-ecological zones, based on a combination of annual temperature and rainfall, which covers a large area of the western sections of the Abbay Gorge, the lower Didessa valley and the lower Beles valley (Figure 4.9).



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006

Figure 4.9 : Agroecological Zones of Abbay basin

4.2.2 Terrestrial Vegetation and Habitat

Reconnaissance surveys were made of the Mandaya potential reservoir area in October (aerial survey along the complete 300 km length), in November and December 2006, January 2007, and in the Mandaya dam site area in March 2007 when access became available by boat from Boka.

The natural terrestrial vegetation of this area may be classified physiognomically as woodland. Within this vegetation type, there are three general plant associations: *Combretum – Terminalia* woodland, Riverine forest and Lowland bamboo (*Oxytenanthera abyssinica*) forest.

The reservoir basin is dominated by *Combretum – Terminalia* woodland (Plates 1 and 2).

Combretum – Terminalia woodland

The *Combretum – Terminalia* woodland vegetation covers a vast area around the potential Mandaya reservoir area. This is a deciduous vegetation type with a canopy height reaching 8 – 12 m.

It comprises mainly tree species that include *Anogeissus leiocarpa, Boswellia papyrifera, Combretum collinum, Combretum hartmannianum, Cussonia ostinii, Entada abyssinica, Erythrina abyssinica, Pterocarpus lucens, Strychnos innocula, Oxythenantera abyssinica, Terminalia collinum, Sterospermum kunthianum* and *Acacia polyachantha*. Of these trees, *Anogeissus leiocarpa* and *Acacia polyachantha* are among the most dominant species along the river. There is a shrub layer that is not so well defined consisting of *Grewia mollis, Maytenus sengelensis, Pliostigma thoningii, Gadenia ternifolia, Fluggeaea virosa,* etc. Distinguishable herbaceous plants present include grasses such as *Pennisetum polystachion, P. schweinfurthii* and *Sorghum arundinaceum*.

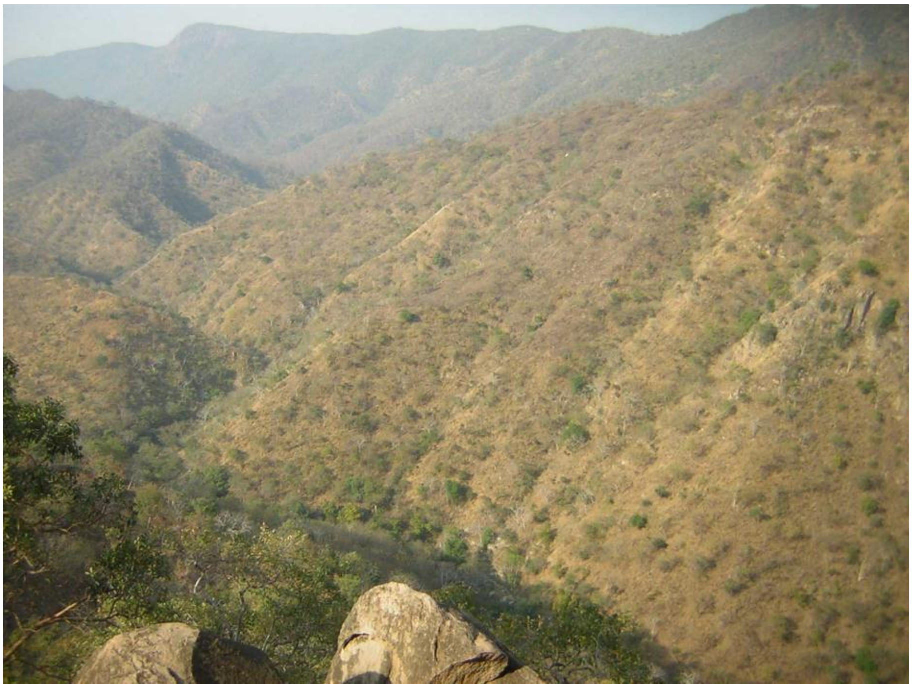
The economically important incense tree species, *Boswellia papyrifera*, and the lowland bamboo, *Oxytenanthera abyssinica* have important investment potential in future.

Natural and human induced firing influence the woodland cover in the project area. The woodland is continually changing to cultivation as more and more Gumuz people turn to a sedentary way of life and crop production becomes the main means of family subsistence.

Seasonal burning is largely determined by the availability of ignition and seasonal variation in flammability (Waring and Schlesinger, 1985). Vegetation is deliberately burned in order to stimulate new and fresh growth, and to control ticks and snakes while preparing land for cultivation. According to Vickery (1984) the natural balance of soil is considerably altered by fire, which removes the humus from the surface of the topsoil, destroys micro-organisms, and increases the concentration of salts. It also affects succession, disrupts the natural stability of the original climax community. Ewusie (1980) indicates that fire, next to climate and soil, to be the most important single factor affecting the extent, composition, and character of forest and other vegetation cover on wild land.

Plate 1: Dry season vegetation at Nekemte-Bure bridge – uppermost end of Mandaya reservoir

Plate 2: Dry season vegetation at Nekemte-Bure bridge – uppermost end of Mandaya reservoir



Riverine vegetation

The riverine vegetation at Mandaya dam site is distinctly conspicuous in the dry season. It is dominated by *Ficus* species. At the dam site the river flows in a relatively narrow channel and the riverine vegetation is distinct in its evergreen-ness in contrast to tree species along the steep valley escarpments that are mainly deciduous, shedding their leaves during the dry season (Plate 3).

Typical trees in the riverine forest at the dam site and along a few kilometres upstream comprise species of *Acacia polyacantha, Tamarindus indica, Tamarindus africana, Teclea nobilis, Kigelia aethipioca* and *Cordia africana*. According to the Woody Biomass Inventory and Strategic Plan Project report (WBIPP), the area covered by riverine vegetation is very small in the reservoir area.

Plate 3: Riverine woodland and deciduous Combretum woodland in Mandaya gorge near dam site

Lowland bamboo (Oxytenanthera abyssinica) forest

Endemic lowland bamboo (*Oxytenanthera abyssinica*) forest is a unique formation in Ethiopia, and covers a very large area in Benishangul Gumuz region. This forest covers an extensive area lying west of Chagni, Bambasi and upstream of Dabus river near Asosa town. The lowland bamboo forest is a vegetation of unique importance not only to Ethiopia, but it represents a significant proportion of the whole bamboo vegetation present in the African continent. Our survey coverage of the potential Mandaya reservoir area was limited but isolated bamboo patches were observed. According to the Woody Biomass Inventory and Strategic Plan Project report (WBIPP), the area covered by lowland bamboo is very small in the reservoir area.

Endemic Plant Species

The species list obtained from this preliminary survey and from references contains no endemic species, nor species considered threatened. However, detailed surveys along many traverses will be necessary in future before authoritative statements about endemicity and threatened species can be made.

Woody Biomass in Mandaya reservoir area

Mapping in the Woody Biomass Inventory and Strategic Plan Project report (WBIPP) has been analysed for the Mandaya reservoir area (73,600 ha) using GIS for this study. Results are given in Table 4.12.

According to the woody biomass inventory, "dense" vegetation covers 49% of the reservoir basin. Dense woodland and dense shrubland are dominant within the four categories shown. The total area of dense bamboo (160 ha) and riverine forest (only 21 ha) are relatively very small indeed.

Open woodland and open shrubland together cover 32% of the reservoir basin area. Thus, about 80% of the total area is covered in by dense and open woodland, and dense and open shrubland. These areas are the *Combretum* shown in generally leafless condition in the Plates 1, 2 and 3.

Table 4.12 : Land Use/Cover of Mandaya reservoir area with FSL 800 masl

Land Cover	Land Use Category	Land use Area ha	Land cover Area ha	Land cover Area %
Cultivation	Intensely Cultivated Moderately Cultivated Sparsely Cultivated	2600 522 922	4,044	6
Dense vegetation	Dense Bamboo Dense Shrubland Dense Riverine Forest Dense Woodland	160 16,110 21 20,074	36,365	49
Exposed rock	Rock outcrops	989	989	1

Land Cover	Land Use Category	Land use Area ha	Land cover Area ha	Land cover Area %
Grassland	With Few Stocks of woody plant With Light Stocks of woody plant With Moderate Stock of woody plant	12 1327 3320	4,659	6
Wood/Shrubland	Open Shrubland Open Woodland	12,947 10,465	23,412	32
Water	Water body	4,131	4,131	6
All/Total	**Entire reservoir area**	**73,600**	**73,600**	**100**

Source: WBIPP (2003) and GIS this study

It is noted that three land use categories (cultivation, grassland and water surface) each cover about 6%, making up most of the rest of the area. This seems more or less consistent with observations made during the aerial survey in October 2006 but perhaps gives a greater cultivation area (some 4,000 ha) than seen during the aerial survey, and is much greater than our assessment (790 ha) made during subsequent socio-economic surveys. Nonetheless, by all accounts, the area of cultivation is relatively very small.

It may be noted that the water surface area (4,131 ha) mainly refers to Abbay but will also include surface areas of Didessa and some generally small tributaries. Adopting an estimated total length of the reservoir as 300 km, the average width of water surface is about 140 m. This relatively narrow width reflects the character of the main river incised into the bottom of the gorge.

For scoping purposes, and anticipating that clearance of much of the woody vegetation in the Mandaya reservoir will be required, reference has been made to tree densities, tree sizes and basal areas in the WBIPP report. As a general statement, tree density along the Abbay is in the order of 115 trees per ha - a low value. The number of individual woody species per ha within five classes of diameter at breast height (DBH), where DBH is measured at 1.4 m height, is shown in Table 4.13.

Table 4.13 : Density of woody vegetation in DBH classes

DBH cm	Density No. /ha	Basal Area m^2/ha	Distribution %
≤ 10	7	0.76	6
10 < 20	12	1.31	10
20 ≤ 30	33	3.62	29
30 < 40	31	3.40	27
≥ 40	32	3.50	28
All	115	12.6	100

Source: WBIPP report (2003)

When considering this DBH and density data, while it provides some idea about the relatively low numbers and generally small sizes of trees along the Abbay, it may not represent average conditions in the potential Mandaya reservoir area. Also, the suppressed density value of woody species below DBH 10 cm may reflect the impact of fire, killing off the very small individuals which are more susceptible to burning.

The WBIPP report indicates that the corresponding sum of all basal areas of tree species is 12.6 m^2 /ha. This is a low value indicating the prevalence of small sized individuals and may be compared to 23 – 37 m^2 /ha which is considered the normal value of basal areas for virgin tropical rainforests (with much greater rainfall and without a distinct dry season) in Africa (Dawkins, 1959, cited in Lamprecht, 1989).

The average canopy height of vegetation varies and depends on species, topography and slope conditions. The trees on very steep slopes attain moderate stature with average heights of 7 - 8 m.

Whilst this description provides a general assessment of biomass conditions in the potential Mandaya reservoir area, it is not considered adequate to make a preliminary estimate of the volume of standing timber and related root biomass below ground. Such estimates would require detailed traverse surveys throughout the potential reservoir basin.

It is noted that reservoir basin clearance is now occurring in Ethiopia. The Gilgel Gibe hydropower project is mentioned as an example. In this case, the reservoir clearing task was tendered and a contract awarded with strict monitoring by the World Bank and funding agencies and also by EPCO and the Ethiopian Environmental Protection Agency (EPA). The latter is developing momentum for enforcing mitigation measures prescribed in EIA reports, especially for large projects.

4.2.3 Fauna

Fauna observed during the field visits included baboons, guereza, hippos and crocodiles. Local people and woreda agricultural officers indicated the presence of species such as the greater kudu, leopard, common bushbuck, duiker, roan antelope, lion, baboons and warthog. These are animals that are typical of savannah woodland habitats. Assessment of wildlife requires different approaches for different animals, and will require an extended period of observation that needs to be considered in future studies.

The Abbay river basin is regarded as an important area for a wide variety of resident and migratory water birds. The area is particularly important for water birds and watering grounds of large number of migrants. Very many Palaeo-arctic migrant birds cross the Sahara desert from Europe and Asia using the area for feeding and wintering. As the area is significant in the national and international context, and because Ethiopia is a signatory state to the African-Eurasian Waterbird Agreement (AEWA), particular care is required to ensure the protection of these species throughout their natural range.

The Dabus valley controlled hunting area is located downstream of Mandaya dam site. It was listed in 1996 as a tentative candidate to become designated as an Important Bird Area of Ethiopia. Consultations with the Ethiopian Wildlife and Natural

History Society for this study confirmed that this aspiration continues but a decision on promoting Dabus Valley as a designated Important Bird Area continues to be deferred until such time as surveys are conducted and a proper assessment is made.

Information on insects, reptiles and other fauna in the area is similarly severely limited.

Among the reported species of mammals and birds, none are recorded to be endemic to the project area and none are critically threatened. However, the fauna database is inadequate in all aspects and an extended period of surveys will be required to raise the level of information to an acceptable standard for impact assessment. It is noted that such surveys should include not only the potential Mandaya reservoir and dam site areas but adjacent areas from which and to which seasonal migrations may occur. Also, surveys should include the lower Dabus Valley controlled hunting area where survey results may assist the Ethiopian Wildlife and Natural History Society in determining the status of the area regarding its future designation as an Important Bird Area.

4.2.4 Wetlands

Based on field investigations and reviews of collected data, there exists no permanent wetland in the Mandaya project area other than the Abbay river and perennial tributaries. In the river reaches where seasonal flooding occurs, the flood recession areas are used for crop production and no vegetation typical of wetland ecosystems is found.

4.2.5 Protected and Conservation Worthy Areas

Ethiopia is endowed with rich floral and faunal resources, and possesses some of the richest endemic fauna and flora in the African continent. This occurs as a result of the immense topographic and climatic diversity in the country. Ethiopia's biodiversity is illustrated in Table 4.14.

Table 4.14: Biodiversity in Ethiopia

Category	Species in Ethiopia Approximate number No.	Proportion of species endemic in Ethiopia %
Higher plants	6,500 – 7,000	12
Mammals	277	31
Birds	862	17
Reptiles	210	9
Amphibians	63	24
Fish	150	4

Source: Tefetro, EPA Magazine, August 2004

With regard to birds, Ethiopia provides habitats for more than 862 species. Of these 17 are wholly restricted to Ethiopia and are thus endemic. 14 others are shared with Eritrea. Of the Palaeo-arctic migrants, some 45 over-summer in Ethiopia. A large number of these birds have breeding populations in Ethiopia. The biology of many obvious and common endemic bird species remains poorly known. The nest and eggs of several are not described. The ecology, behaviour and breeding biology have not been fully documented, or there is no information. This background requires developers to conduct adequate surveys as part of good EIA practice, and employ experts for surveys who are aware of this background.

Accordingly, Ethiopia has issued a number of regulations aimed at conserving and protecting the remaining natural ecosystems of the country. These protected areas have been divided into four categories according to management objectives: National Parks, Game reserves, Sanctuaries and Controlled hunting areas. Many of the species of plants and animals in Table 4.14 are found in the protected area system (Table 4.15). The Dabus Valley controlled hunting area, downstream of Mandaya dam site, is the nearest protected area to the project.

Table 4.15: Protected and Managed Protected Areas in Ethiopia

Total Protected Area km^2	Managed Protected Area km^2	%
194,000	30,316	16

Source: Tefetro, EPA Magazine, August 2004

The Dabus Valley controlled hunting area has been registered by Ethiopia with the World Commission on Protected Areas (WCPA) which maintains a world database of protected areas. Dabus is registered as Site Code 13752. The Dabus valley area is 1,227 km^2 and, so far as we have been able to ascertain, falls into the “unmanaged” category of protected areas in Ethiopia. Its size is one and a half times larger than that of habitat which would be lost in Mandaya reservoir. Being “on the doorstep” of Mandaya, it appears to be a strong candidate for surveying to a high standard during any follow up feasibility studies and later assisting continuing development of a management system for it as part compensation and as an environmental offset for destruction of habitat in Mandaya reservoir, quarry and other works areas. Websites provide little information on plants and animals, though elephant and lions are mentioned. This lack of detailed information supports the concept of a future hydropower project entering into a partnership arrangement with wildlife authorities in the area’s biodiversity conservation and management and for future ecological surveys for the hydropower project including the Dabus protected area.

Limitations of surveys

An overview of terrestrial ecology of the project area has been given but this is not regarded as sufficient for project implementation.

The aerial survey was very valuable but access on foot was limited in the time available to the upper end of the potential reservoir where there is road access, and to the dam site area, and some kilometres upstream, where access was by inflatable boat. (See Appendix).

Surveys were made in the dry season when most plants had withered and shed their leaves making identification very difficult. Also, visits coincided with periodic fires that are characteristic of the project environment. Most of the areas visited were either recently burned or were still burning during the field study. Future surveys require much more time and timing after the rains when plants have full foliage and many are in flower to assist identification.

However, in spite of survey limitations, it has been possible to identify terrestrial ecology concerns that are relevant, and thus provide direction for planning and executing detailed surveys in future.

4.2.6 Aquatic flora and fauna

Available baseline data for aquatic biota other than fishes is desperately poor. The data for fish is comparatively better.

Phytoplankton

Samples taken in March 2007 from Abbay river at an island between Boka and Abagole, located some 15 km downstream of the Mandaya dam site, as well as samples from the Mandaya dam site, indicate the dominance of diatoms of different genera (Appendix 4.1). There is also indication of the presence, to a smaller extent, of blue green and green algae.

Samples taken from the Abbay at the Bure-Nekemte bridge indicate the dominance of diatoms and the presence of some blue green and green algae (Appendix 4.2).

Talling & Rzoska (1967, in Morris *et al*, 1976) have also reported the presence of rudiments of phytoplankton especially *Cyclotella* in the Abbay river below Tisissat Falls. However, generally, there is little prospect of permanent plankton populations being established along considerable stretches of the Abbay river (Morris et al, 1976).

Observations of the Blue Nile in Sudan indicate that very little of the headwater lacustrine phytoplankton survive and prosper after the descent to the Sudan plain. The Lake Tana plankton was scantily represented at the Tissisat Falls, and not seen at all at a station further down the Abbay gorge. In the gorge, the phytoplankton appears to be present in low densities. According to Talling (1976) it is composed predominantly of the diatom *Melosira granulata* and its elongate variety *angustissima*, with smaller numbers of the blue green *Lyngbya limnetica* often accompanied by *Anabaena flos-aquae*.

Macrophytes are only seen in relatively static areas out of the main stream and in tributaries.

Zooplankton and benthos

Due to the rocky and turbulent nature of the Abbay River, it is unlikely that a population of zooplankton is established in a considerable proportion of the river. The benthos of the Abbay is generally believed to be poor mainly because of the drastic changes in flow rates and water level.

Samples taken in March 2007 from Abbay river at an island between Boka and Abagole, located some 15 km downstream of the Mandaya dam site, as well as samples from the Mandaya dam site, indicated the presence of two zooplankton species, namely, *Mesocyclops* sp. and *Cyclopoid nauplii*.

In a recent survey conducted on Beles River at Babizenda, *Diaphinosoma* and *Thermocyclops* of the zooplankton community and *Chironomids*, mayflies, beetles, dragonflies, water penny and stoneflies of the Arthropod community have been recorded.

Samples taken from under the Bure-Nekemte Bridge, further upstream, revealed the presence of no group of zooplankton. Due to the rocky and turbulent nature of the river, there is little probability of the presence of established communities of zooplankton. The benthos of the Abbay, likewise, is believed to be generally poor because of the steep riverbed and banks in places and the drastic changes of water level.

Fish and other aquatic life

Fish collections were made in March 2007 from Abbay river at an island between Boka and Abagole, downstream of the Mandaya dam site. About 150 specimens were caught - most of them small specimens captured by beach seine. 10 species were recorded belonging to six families (Appendix 4.3). They differ to some extent to fish species reported from Bure-Nekemte Bridge by JERBE (Appendix 4.4).

Some of the species, especially of the Family Cyprinidae, are migratory and need smaller streams for reproduction. Although it is very difficult, indeed impossible without detailed studies, to determine which tributaries these fishes go to and use for spawning, it is considered that some or all of the local tributaries in the 25 km Abbay reach between Boka and Mandaya dam site (e.g. Boka, Sirba, Geli, Jali and Gember on the left bank, and Dura and Mecha on the right bank) could serve as breeding grounds during the rainy season. At the time of sampling, only Boka tributary was flowing, the others being dry.

Anecdotal information from a missionary nurse, resident for two years at Boka, indicated that fish of between 10 to 12 kg are caught in Abbay river locally, whilst smaller fish are caught in tributaries. Also, she reported that in some years a small silvery fish enters tributaries from the Abbay, and these tributaries become “crowded” with these fishes which villagers catch continuously over a long time. She reported that villagers say that these fish come from Sudan. In all cases, the names of the 10-20 kg and the small fish species, and of those which can sometimes “crowd” tributaries which are believed to migrate from Sudan, were not known. This anecdotal information became available after field surveys were completed in March 2007 and will require following up in any further investigations.

A recent repeated survey of Beles river at Babizenda, made by the consultant and a postgraduate student at Addis Ababa University, has indicated 23 fish species belonging to seven families (Appendix 4.5).

The Joint Ethio-Russian Biological Expedition (JERBE) reported 24 species in Abbay river, some 35 km from Mankush (Appendix 4.6). Fish samples taken by JERBE from the Dabus river at the bridge along Nekemte-Asosa road, indicated the presence of seven fish species, mainly of the East African forms (Appendix 4.7). JERBE also surveyed Abbay river at Bure-Nekemte bridge located much further upstream. Six families with 15 species were recorded (Appendix 4.4). Most of the species (e.g. *Mormyridae, Bagridae*) are Nilo-Sudanic forms while few (e.g. *Labeo, Barbus intermedius, Garra spp*.) are East African forms. Many of the fish species are adapted to life in turbid and muddy waters.

Because of the difficulties in the accessibility of the Abbay gorge below the Tisissat Falls, few fish diversity studies have been conducted through the years. On the other hand, the fish fauna and other aquatic life of the Abbay River above Tisissat Falls has been thoroughly studied and identified. The two sets of fauna are believed to be quite different from each other although there are some common elements.

During the Abbay river expedition through the Abbay Gorge, including the Mandaya gorge, in 1968 biologists reported an apparent general scarcity of fish in the Abbay and attributed this to the extreme force of the currents and muddiness of the water. They considered that food for fish must be in short supply, the currents sweeping away any small prey or suspended matter, though during the dry season there is probably an abundance of insect larvae in the shallow river water. Another indication of fish scarcity was the small number of fish predators seen. A few egrets, herons, fish eagles and crocodiles were observed but these were relatively infrequent compared with their abundance in waterside habitats elsewhere in other drainage basins in Ethiopia. Very few other common riverside species of birds were seen, also suggestive of food shortage (Morris *et al*., 1976, citing the Great Abbay Expedition in 1968).

Observations at the Bure-Nekemte Bridge revealed that large freshwater molluscs (from their shells) and at least two species of lizards (from live specimens) inhabit Abbay riverbank areas.

During surveys made in March 2007 in the Abbay reach near Mandaya, hippopotami were observed to be abundant and crocodiles present in various locations (Appendix 4.8). Storks, herons, finches, guinea fowl, guereza and baboons were also seen at the upper end of this reach.

Earlier reported observations along Abbay further upstream (Morris *et al*, 1976) confirm the presence of aquatic animals, such as *Hippotamus amphibious*, Nile monitor (*Varanus niloticus*), Nile crocodile (*Crocodylus niloticus*), leathery turtle (*Trionyx triunguis*) and the side-necked terrapin (*Pelomedusa subrufa*). A golden frog (*Ptychadena huguettae*) was also reportedly collected by the Didessa River. Another frog species (*Rana occipitalis*) was collected at Sirba (where the Great Abbay Expedition ended, close to Boka). The widely distributed freshwater crab, *Potamonautes antheus*, has also been reported (Williams, 1976).

Insects (especially mosquitoes) were noticeably scarce during the wet season (October and November 2006 were unseasonably wet), but earlier travellers have reported plagues of them (Morris *et al*., 1976) and, as will be seen later, malaria is rife in the area. It may be presumed that the principal aquatic insects are those with short life cycles that can develop during the dry periods in great numbers, be flushed out by the rains, and later swiftly re-colonize the river from small reservoir populations in backwaters.

Endemic species

There are no endemic aquatic species so far reported from the area of the Mandaya dam site, reservoir area or downstream in Ethiopia. However, it is noted that this assertion is based on incomplete baseline data. Rare species, with restricted range distributions, are not easily sampled and brief surveys can easily miss these species.

4.3 SOCIO ECONOMIC AND CULTURAL ENVIRONMENT

4.3.1 Administrative Framework

Background

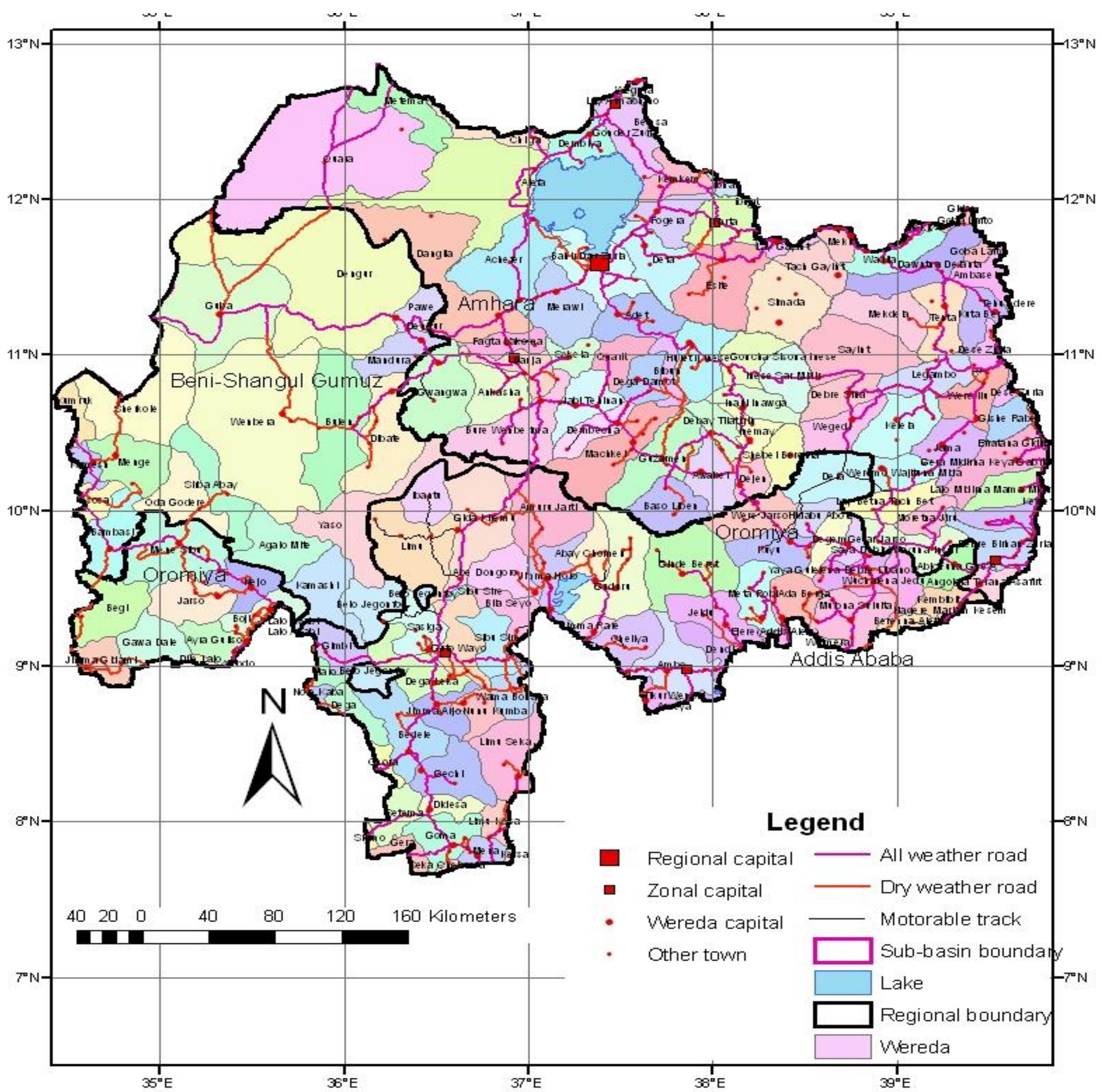
Following the 1993 change of government in Ethiopia, a federal government system was established in the country. The federal system allowed the establishment of regional governments based on ethnicity, commonly known as regionalization.

The regionalization process is one of the key steps of decentralization intended to achieve three important goals in the country:

- to ensure equitable development for all the regions,
- to correct the past system of governance that is characterized as urban biased, ethnic intolerance and neglect of infrastructure and social development, and
- to ensure increased participation and balanced economic growth.

The regionalization process gave power to the regional states to develop and manage their natural resources.

Nine regional states and two administrative councils were formed under the federal government. The Mandaya project area lies almost completely within Benishangul Gumuz Regional State. The north bank of the upstream end of the reservoir is in Amhara Regional State, and a very small area of the south bank (measured in hectares rather than square kilometres) at the uppermost end of the reservoir is in Oromia Regional State (Figure 4.10). As the tail of the Mandaya reservoir in this extreme uppermost reach will be within the existing river channel, and surveys found no impacted settlement or property in this area, the following description of states is limited to Benishangul Gumuz and Amhara.



Source: Ministry of Water Resources

Figure 4.10 : Administrative Areas of Abbay river basin

Benishangul Gumuz Region Administration

Benishangul Gumuz Regional State has a surface area of 50,380 km^2. The Region has an international boundary with Sudan in the west and has borders with Gambella, Amhara and Oromia Regions.

Benishangul Gumuz has a total population of 625,000 inhabitants (2006 estimate) of which about 93% reside in rural areas and the remaining 7% in urban areas. Population density of the Region is 9.3 persons per km^2.

The region is administered by a council and contains three zones, 18 woredas and two special woredas and 474 kebele councils. The woredas are shown in Figure 4.11.

River Abbay divides the region into two parts. The northern part consists of Guba, Wonbera, Bulen, Dangur, Dibate Mandura, and Pawe Special Woreda. The woredas south of Abbay comprise Sherkole, Sirba Abbay, Kurmuk, Komashi, Menge, Asosa, Bambasi, Oda Godere, Agelo Miti, Yaso, Kemashi, Belo Jegenfoy, and Mao Kumo Special Woreda.

Amhara Region Administration

Amhara Regional State is located to the north of Abbay river in the upper reaches of the Mandaya reservoir area. The land mass of the region is about 170,152 km^2. The Region is divided into eleven administrative zones, which are further subdivided into 113 woredas. The eleven administrative zones are: North Gonder, South Gonder, West Gojam, East Gojam, Awie, Wag Hemra, North Wollo, South Wollo, Oromia, North Shewa and Bahir Dar City special zone.

The Amhara regional state has a population of some 19 million people which constitutes about 25% of the population of Ethiopia.

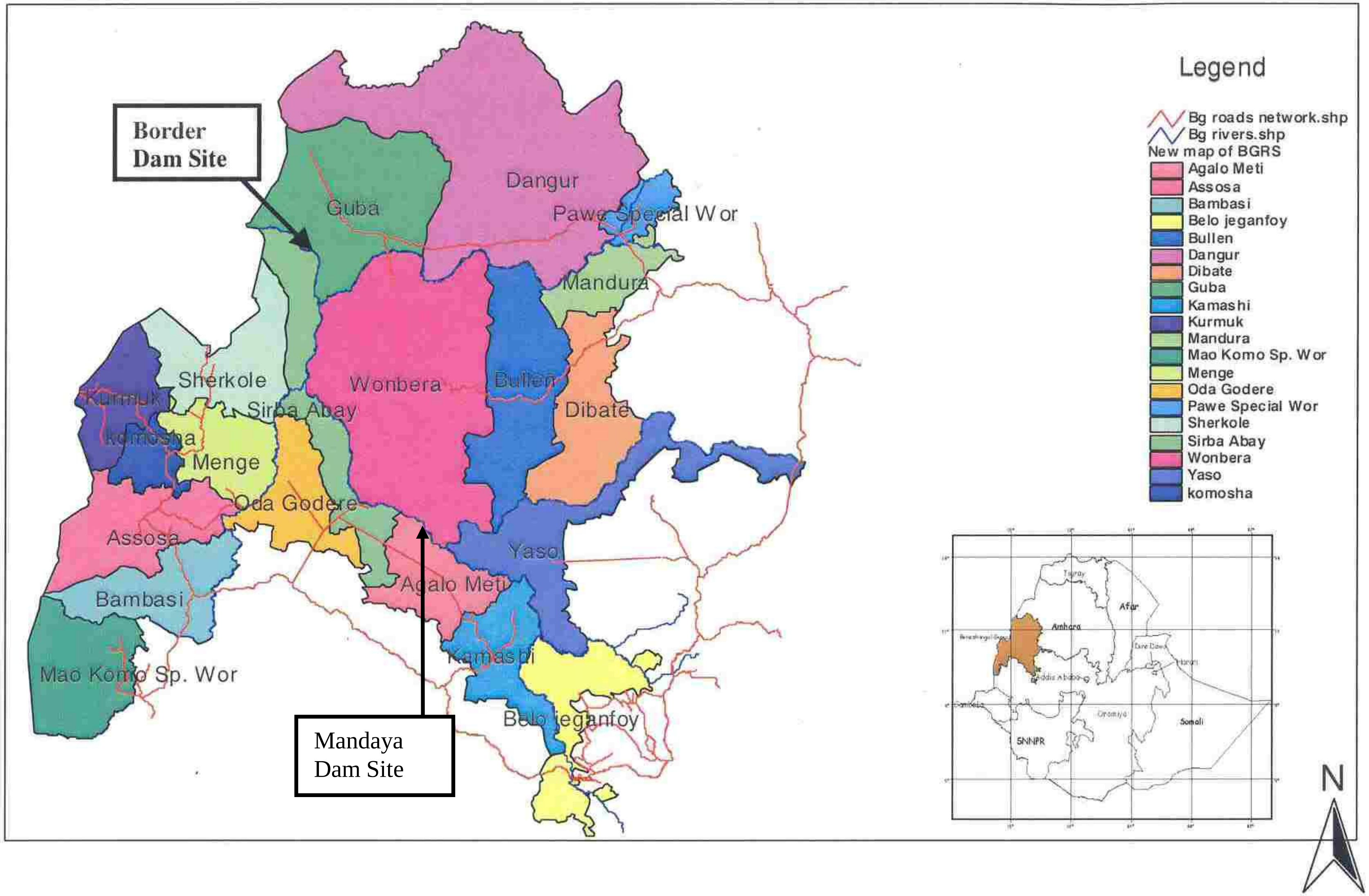
With regard to settlement patterns, 89% of the people of the region reside in rural area. Although the region's population density (120 persons per km^2) is unevenly distributed, it is on the high side in relation to the country's average density.

The major economic activity is subsistence agriculture. In 2003, agriculture contributed some 62% of the regional GDP, followed by industry and services contributing 23% and 15% respectively.

The Abbay river has a total length of about 800 km (National Atlas of Ethiopia, 1988). Some 300 km of this length would be affected by Mandaya reservoir at the proposed Full Supply Level (800 masl).

Major tributaries of the Abbay river within the three regions are Dabus, Belles, Dura, Jilla, Belbete, Quall, Mankussa, Debuha, Kokil, Gublak, Hoha, Didesa, Sherkole, Anger, Waga, Fincha, Guder, Muger, Jemma, Welaka, Beshiloa and Fetam.

The following summary of the socio-economy of the area has been developed in close collaboration with the government departments of the three regions and in consultation with communities.



Source: GIS/RIS (BoFED) of Benishangul Gumuz

Figure 4.11 : Administrative Areas of Benishangul Gumuz Region

4.3.2 Organizations Operating in the Project Area

Government Organizations

A full range of government departments operates in each of the Mandaya project area woredas. The departmental arrangements are identical in each woreda, as shown below:

1. Agriculture and Rural Development Office
    - 1.1. Crop Development and Protection Team
    - 1.2. Extension and Economics Team
    - 1.3. Natural Resources Development and Protection Team
    - 1.4. Livestock and Fishery Team
    - 1.5. Drinking Water Desk
    - 1.6. Food Security, Resettlement, and Disaster Preparedness Desk
    - 1.7. Rural Road Desk
    - 1.8. Cooperative and Expansion Desk
    - 1.9. Micro and Small Scale Trade Desk
2. Education and Capacity Building Office
3. Health Office
4. Administration and Justice coordination Office
5. Militia Office
6. HIV/AID office
7. Justice Office
8. Information and culture office
9. Court Office
10. Finance and Economic Development Office
11. Public Relations Advisory Office
12. Revenue Office

Ethnic and Political Organizations

There are a number of ethnic and political organizations operating in the project area. Accordingly, there are four ethnic based organizations in Benishangul Gumuz regional state functioning under the leadership of "Benishangul Gumuz People's Democratic Front". Among the four, two political organizations are fully operating in the project target area. The four organizations are:

1. Boro Shinahsa People's Democratic Movement operates in Metekel Zone;
2. Ethiopian Berta People's Organization operates in Asosa Zone;
3. Gumuz People's Democratic Organizations operates in Metekel and Kamashi;
4. Mao Komo People's Democratic Organization operates in Mao Komo Special Woreda.

In Amhara, there is one major political organization, namely the Amhara National Democratic Movement (ANDM). Oppositions also exist in the region but their extent in the project area is not clear. There are also several development organizations in Amhara such as Endeavour, Organization for Relief and Development in Amhara (ORDA), Amhara Credit and Saving Institutions (ACSI), Amhara Development Association (ODA) and others.

Community Based Organizations

Major community based organizations of the affected woredas are kebele and sub-kebele. The kebele or the sub-kebele is a basic structure under the woreda administration. Each has its own administrative organ consisting of a chairperson, an assistant as well as a secretary. This organization is responsible for mobilizing people under their jurisdiction for any development work.

In addition, the kebele or the sub-kebele may consist of voluntary associations like the Idir, Ikub, etc which are mainly instituted to create cooperation and mutual assistance among members.

NGOs

According the CRDA compilation report, about 16 NGOs are operating in Benishangul Gumuz, Amhara and Oromia Regions. These are members of the CRDA, but others that are not registered as members are also operating particularly in Amhara. A greater number of NGOs is engaged in Amhara region than Benishangul (Table 4.16). Activities of those in service in the project area are education, health, water, harmful traditional practices and, in rare cases, integrated development.

Table 4.16 : NGOs operating in Mandaya project area woredas

Name of NGO	Origin	Intervention	Host Woreda
Amhara Development Associations (ADA)	Local	Health, education, basic skills	Whole of Amhara
Anti-Malarial Association (AMA)	Local	Malaria eradication	Whole of Amhara
Association for Development and Construction of Dessie and the Environs (ADCDE)	Local		Whole of Amhara, woreda
Canadian physician for AIDS and Relief	International	AIDS, medicines	Dibate
Catholic Relief Service – Ethiopia program	International	Financier	Sherkole
Mujejeguura Loka Harmful practices on Women Organization	Local	Genital Mutilation, Women's Rights	Guba
Comitato Internazionale Per Il Sviluppo de Populi (CISP)	International	Integrated Development	Bullen Dibate
Communita Volontari per Il Mondo (CVM)	International	Integrated Rural Development	East and West Gojam
Ethiopian Catholic Secretariat (ECS)	Local	Health, education	Sherkole, Guba

Name of NGO	Origin	Intervention	Host Woreda
Integrated Service for AIDS Prevention & Support Organization	Local	AIDS, health	Amhara, Oromia target area
Norwegian Church Aid (NCA)	International	Integrated development	Sirba Abbay
Organization for Social Service for AIDS (OSSA)	Local	AIDS	Amhara, Oromia
Voluntary Service Overseas (VSO)	International	Welfare for street mother & children	Sherkole
Rehabilitation and Development Organization (RDO)	Local	Provision of Physical Rehabilitation	Sherkole
ZOA Refugee Care	Local	Refugee	Sherkole, Guba
OXFAM/GB	International	Livelihood improvement	Various areas

4.3.3 Population Characteristics

Population Size and Structure

The Mandaya dam site is located in Benishangul Gumuz Regional State and its reservoir area extends to Amhara Regional State. The woredas affected by the project are seven in number from the two regions. Out of the seven, five woredas (Agalo Meti, Yaso. Dibate, Bulen and Wonbera) are in Benishangul Gumuz Region, and two woredas (Guangua and Wonberma) are in Amhara Region.

Based on Population and Housing Census undertaken by CSA in 1994, the population of these woredas is now estimated at 675,905 (Statistical Abstract, 2005-2006 estimates). Summary statistics on sex composition and population density are shown in Table 4.17.

Table 4.17 : Population characteristics of Mandaya project area woredas

No	Woreda Name	Population			Woreda Area	Woreda pop Density	Mandaya Reservoir Area		
		Male No.	Female No.	Total No.	km^2	P/ km^2	Area of woreda in reservoir km^2	Area of woreda in reservoir %	Area of reservoir in woreda %
1	**Benishangul G.**								
	Agalo Meti	9,350	9,474	18,824	1,519	12.4	133	9	18
	Yaso	5,155	5,153	10,308	2,789	3.7	323	11	44
	Dibate	28,078	28,212	56,290	2,425	23.2	81	3	11
	Bulen	14,654	14,654	29,308	2,858	10.2	30	1	4
	Wonbera	27,409	28,851	56,260	7,135	7.9	143	2	19
	Sub-total	**84,646**	**86,344**	**170,990**	**16,725**	**10**	**710**	**4**	**96**

No	Woreda Name	Population			Woreda Area	Woreda pop Density	Mandaya Reservoir Area		
		Male No.	Female No.	Total No.	km^2	P/ km^2	Area of woreda in reservoir km^2	Area of woreda in reservoir %	Area of reservoir in woreda %
2	**Amhara**								
	Guangua	104,292	104,227	208,519	2,162	96.5	16	<1	2
	Bure Wonberma	147,053	149,343	296,396	2,207	134.3	10	<1	1
	Sub-total	**251,345**	**253,570**	**504,915**	**4,369**	**116**	**26**	**<1**	**4**
GRAND TOTAL		**335,991**	**339,914**	**675,905**	**21,094**	**32**	**736**	**3**	**100**

On average, 88% of the population in these woredas reside in rural areas; the remaining in towns.

Regarding household distributions of the seven woredas, the total household number amounts to 60,785 (Table 4.18). The households are not evenly distributed among the project woredas. Wonberma in Amhara has 30% of the total households followed by Dibate and Wonbera with 17% and 15% respectively.

Table 4.18 : Number of households in Mandaya project area woredas

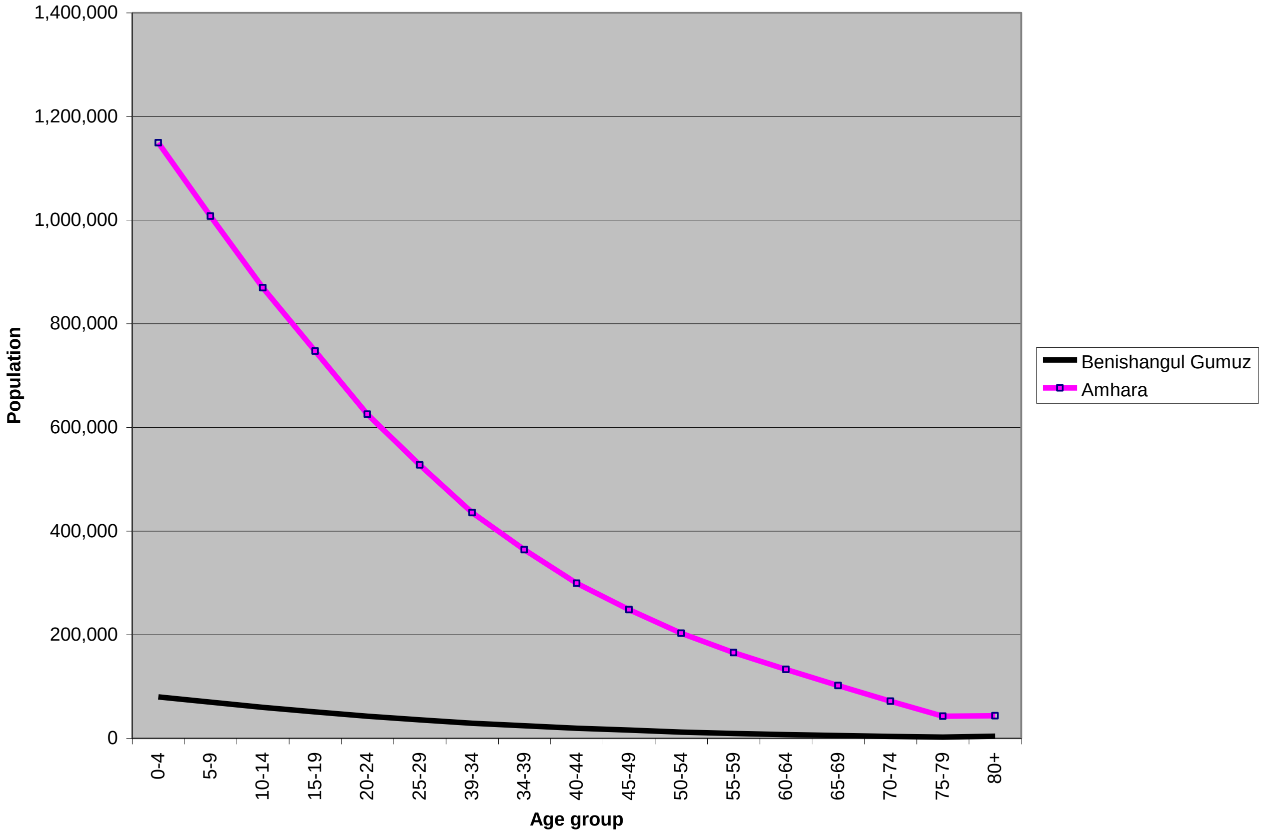
Woreda	Household No.	Household %
Dibate	10,382	17
Bulen	4,659	8
Wonbera	9,271	15
Yaso	2,254	4
Agalo Meti	3,326	5
Wonberma	18,133	30
Guangua	12,760	21
All/Total	**60,785**	100.0

Source: GIS-BoFED of Benishangul Gumuz

Age and Sex Composition

The age group composition of the woredas of the two regions in the project area shows similar age structure as that of the nation. A large proportion of the population in the project woredas is reported to be young people less than 25 years old, of which those under 15 constitute the greater number. The age group composition of the woredas in the project area is therefore closely similar to the age structure of the region (Figure 4.12).

According to the CSA projection of the average national age structure for 2006, 43% of the age groups are less than 15 years old. Individuals that are between 15-65 years old are only 54% of the total population; those over 65 are only 3%.



Source: Compiled from CSA Census Data, 1995

Figure 4.12: Population by Age Group of Benishangul & Amhara Regions

When we come to the two regional states we find that people under 15 years of age constitute about of 80% of the total population in Benishangul Gumuz, and 81% in Amhara.

The age group composition indicates high fertility and continuous population growth where the majority of the population is concentrated within the age group less than 20 years old. Examining the age group 20-50 years, the tree becomes narrow and the older age group (above 65) represent only a small proportion of the total population. This indicates low life expectancy in the Benishangul Gumuz Region.

From the field survey the population in the project area is mostly young people under the age of 15 years old which confirms the CSA data.

The dependency ratio for Benishangul Gumuz is 87% for youth and 6% for old people. The dependency ratio for Amhara (East Gojam-project Zone) is 92% for youth and 7% for old people (CSA, 1999).

Ethnic and Religious Composition

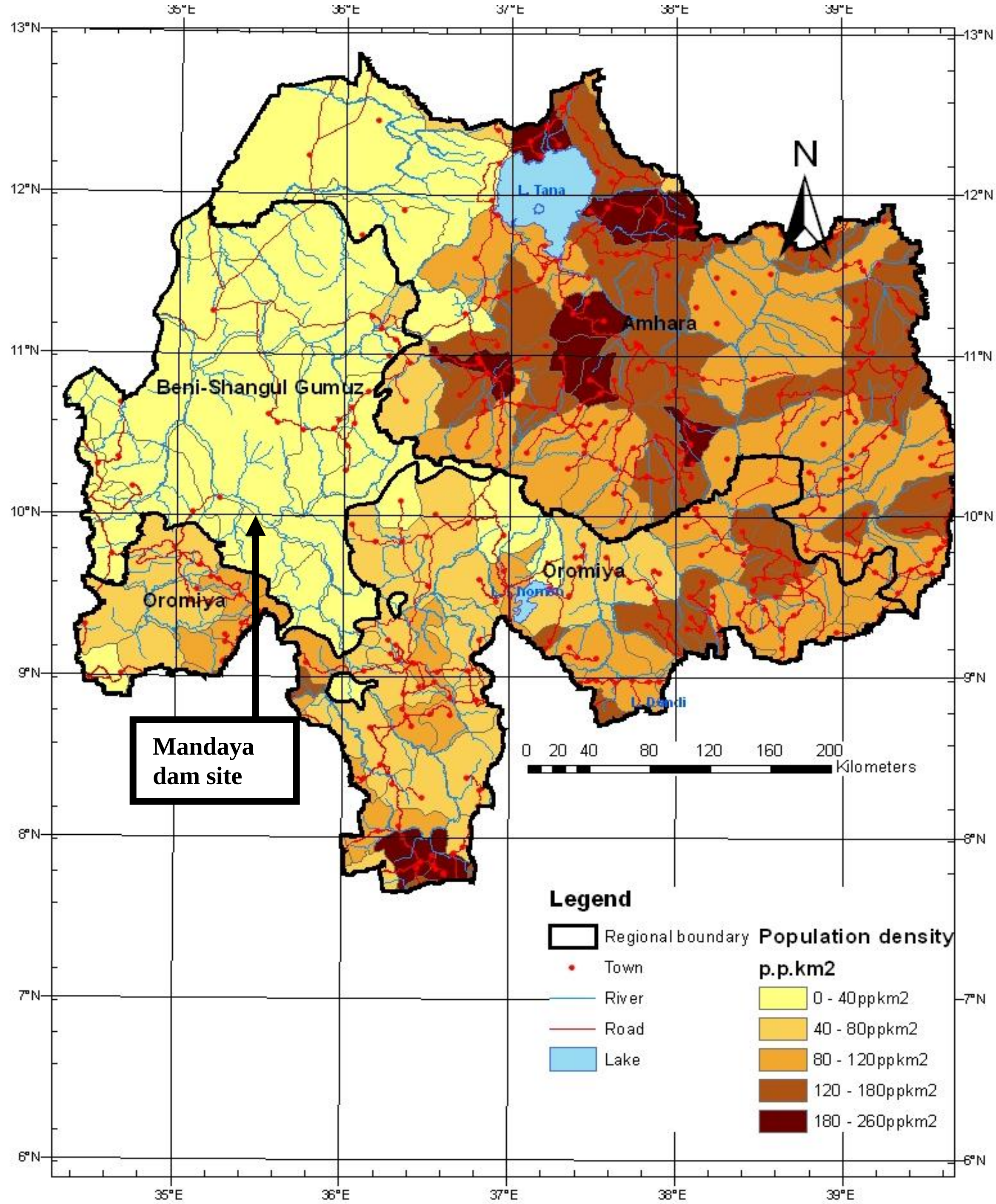
The indigenous people living in the Mandaya project woredas are Gumuz, Berta and Shinasha from Benishangul Gumuz, and Amhara in Amhara. In addition to the indigenous people, other various minority groups are found in both regions. Amhara ethnic group is found in a large number in Benishangul Gumuz resulting from immigration at different times but mainly due to resettlement that took place following the great famines of 1978/79 and 1984/85.

In Benishangul Gumuz, the majority of the people in the project area are Muslim followed by Orthodox Christian and Protestants, in that order. Traditional religion and non-believers are also found, particularly in Benishangul Gumuz. They are very traditional and the oldest of all.

Dominating religious organizations in the Amhara part of the project area are Orthodox Christian with small minorities of Muslim, Protestant and Catholic.

Population Density

The population density of the project area woredas is presented in Table 4.17 (above). The low densities In Benishangul, ranging from about 4 to 23 persons/km^2 are among the lowest in the region and may be seen in the Abbay basin context in Figure 4.13 where the these low densities are seen to be in the lowest (0 – 40 persons/km^2) of the five band classification.



Source: Ethiopia Country Paper, Hydrosult *et al*, 2006

Figure 4.13 : Rural Population Density in Abbay Basin

Settlement Pattern and Housing Condition

The settlement pattern in the project affected area is highly scattered. To cover the distance within sub-kebeles takes hours of walking. Settlements are sparsely distributed.

The settlement pattern poses problems in the provision of infrastructure and other services and a big problem for mobilization, marketing and development interventions. Currently there is a study by Benishangul Gumuz Regional government to resettle the people more closely together, as has been done near Boka in Sirba Abay – downstream of Mandaya dam site.

In Amhara, an additional problem is observed. The settlement areas have reached their carrying capacities. The need for resettlement is mainly due to insufficient resources (land and others) for currently existing communities.

The quality of housing in the project area is very poor. Almost all rural people live in houses made of wood/bamboo and mud with thatched roofs (Plates 4 and 5). By contrast, in towns one can see houses made of wood plastered with mud, and roofs with corrugated iron sheets.

Plate 4: Typical Village Houses in the project area

Plate 5: Gumuz Family in the project area

In Benishangul Gumuz, families normally have houses for the head and spouse, children, cooking house, and others depending on the wealth of the households. However poor a household is, it has at least two houses and the number can reach four. On the average, a household can own three houses.

In Amhara, most houses have one room only that is used for cooking, sleeping for all household members and for keeping animals during night. The number of persons per household is estimated at about six persons on average.

Among the Benishangul Gumuz communities within the study area, in most cases there is no housing for livestock. Cattle are left to wander around in search of their own feed and left alone for a long time, some times even for a year (Plate 6).

The housing situation is completely different in Amhara Regional States. Cattle are penned in or around the houses during the night. It is common to see animals living in the same houses as people in Amhara.

Plate 6: Cattle grazing in the forest in Yaso

Marital Status

Marriage practice depends on the culture of the different ethnic groups and religions found in that place. The majority of the ethnic groups in the project area are the Gumuz. The Gumuz have the tradition of marrying three wives (they are mostly Muslims). Among Christian Gumuz, marriage is one to one. The divorce rate among the Gumuz is reported to be very low (5%) compared to the Amhara. According to the 1994 census of Ethiopia conducted by CSA, the population reported "never married" is about 38%, relatively lower than the Amharas (33%).

Migration

Migrations in the two regions are common but the purposes and degree are various. In Benishangul Gumuz, it is frequently happening and notably higher than in the rest of the country for a number of reasons. The major migration reason to the area is for resettlement. Temporary immigration took place in the past (mostly from the Sudan due to drought and conflicts, trade and other reasons).

The biggest migration in to the region took place after 1984 famine when people from various parts of Ethiopia were resettled there. Table 4.19 shows migration statistics in the two project region in 1999.

In the Amhara part of the project area (Guangua and Wonberma), where people are considered relatively "wealthier" than other parts, very a low migration rate is seen due to the very conservative behaviour of the population. Most of the migrants are within the same region, moving from rural areas to nearby towns.

Table 4.19 : Migration in the Regions by Sex

Region	Gender	Migrants %	Non- migrants %
Benishangul Gumuz	Male	28.3	70.7
	Female	27.9	71.3
	Total	28.1	71.0
Amhara	Male	9.3	90.4
	Female	12.1	87.6
	Total	10.7	81.9

Source: CSA, Population and Housing Census of Ethiopia, 1999

4.3.4 Economic Activities

The main economic activities of the project woredas are subsistence agriculture and animal husbandry.

There are other activities like trade, cottage industry and traditional gold panning, but these are not very significant for people's income generation.

A high prevalence of extreme poverty and low levels of economic and social infrastructure characterize the economic situation of the population living in the target woredas. According to the data obtained from the regions, the following indicators are major characteristics of the areas:

- Low level of per capita income;
- Limited access to health service;
- Low education level and high illiteracy rate;
- Food deficiency and malnutrition; and
- High morbidity and mortality, low life expectancy.

Land Cover and Land Use

Land cover in the potential Mandaya reservoir area comprises mainly dense woodland (27%), dense shrubland (22%) and open shrubland (18%), together covering two thirds of the area. Cultivated land (5%), some of which is sparsely or only moderately cultivated, and grassland (6%) occupy a very small proportion of the area – about the same as the water surface area of the Abbay river and tributaries (Table 4.11, presented earlier).

Agricultural Activity

Agriculture is the mainstay of the people in the project affected woredas.

A survey conducted by Benishangul Gumuz Rehabilitation and Development Associations (BRDA) showed that most households in Benishangul Gumuz region are not able to produce sufficient requirements of food. Only rich farmers (rich is relative here) are able to produce enough food to provide supply all round the year. The rich are reported to provide 90% of their food from their farm (10% is purchased, meat and industrial food products).

The situation in Amhara is slightly different. In Wonberma woreda it is reported by the administration that the yearly income of a person is about 780 USD. This is because Guangua and Wonberma woredas are areas among those receiving sufficient rain falls1. Nevertheless, the livelihoods of the people are difficult.

There are many peasant associations in the projects affected woredas.

An extension program was introduced in the regions in 1993 under SG 2000, where the activities are based on farm demonstration plots managed by farmers themselves. The program consisted of agricultural packages including demonstration plot, technology package, finance (to make them self-reliant), participatory approach, etc. This was followed by an extension package program assisted by extension workers and Development Agents.

The total number of Development Agents in the project area is reported to be 35, excluding Guangua and Wonberma. In addition there are Home Agents and Animal Health Technicians in the area.

Information obtained from the regional Agricultural and Rural Development Bureau shows that the major problems affecting the agricultural sector in the project area (and in the region) are:

- low productivity,
- scattered population of indigenous communities,
- low level of community participation,
- high prevalence of human and animal diseases,
- backward agricultural cultivation systems, and
- inadequate supply of agricultural inputs.

Crop Cultivation

Agriculture including farm cultivation and livestock engages over 57% of the economically active population in Benishangul Gumuz Regional State. The situation in the project affected area is similar to that of the regional figures. The average area used for crop production in the state is 0.36 ha per capita (Bureau of Agriculture and Rural Development).

- [1] In Amhara region woredas are classified as Moisture Deficit or Sufficient Rainfall, depending whether or not the woreda has enough rainfall for cultivation.

The same source shows that the total area used for crop production in the affected woredas amounts to 28,563 ha. Crop production is not evenly distributed in the project affected woredas. Wonbera produces the highest proportion of crops in the area.

Oxen are the main sources of draught power in Amhara Region. A survey conducted in Amhara Region indicated that 92% of the rural households in the project area' utilized oxen to plough their land, but that 23 and 47% of households, respectively, have no ox or one ox (Rural Households Socio-economic Baseline Survey - Phase I, April 2003).

Major crops grown in the project affected woredas are sorghum, maize, pulse, oil seed, sesame and vegetables. The dominant crops are sorghum and maize.

Shifting cultivation is a common practice among the Gumuz population, but in Oromia and Amhara this is not common due to shortage of land. A piece of forest land is always cleared and burned for cultivation in Benishangul, where the forest wood is often stacked and burned to get rid of it, but land clearing for agriculture purposes is not usual practice among the Oromia and Amhara peoples.

The majority of the people use hoes and sticks to prepare the land for cultivation. In Amhara, Shinasha, Agew and Oromo people use oxen power for farming. After a few years of cropping, the land is left fallow to enable the soil regenerate in Benishangul but cultivation is done in the same plot in Amhara and Oromia region.

Irrigation Development

In almost all reaches of the Mandaya reservoir area, the Abbay flows in a gorge and escarpment area that doesn't favour irrigation development. In Yaso and Wonberma woredas of the reservoir area, however, there is limited potential for irrigation development, but the few hectares concerned are insignificant in magnitude. Currently, there exists no irrigation practice (large, medium or small) in the Mandaya reservoir area and immediately surrounding area. The Irrigation development department under the Benishangul Bureau of Water, Mine and Energy Resource Development confirmed absence of operating or planned irrigation schemes in or near the proposed reservoir area.

Recession Agriculture

Field observation and consultations with local people indicated the practice of recession agriculture in Yaso and Wonberma parts of Mandaya reservoir on banks of the Abbay river. The total area flooded during the rainy season is estimated at about 800 ha.

Livestock

The Bureaus of Agriculture and Rural Development in respective regions conducted livestock population, livestock per capita and density surveys in 1998. According to theses surveys, Wonberma has the highest livestock population among the woredas of the project areas, followed by Dibate and Wonbera (Table 4.20). With regard to livestock densities, Yaso has one of the lowest densities in the region as is the case for human population density.

Table 4.20 : Livestock population in Mandaya project area woredas

Woreda	Number of Livestock							
	Cattle	Sheep	Goat	Horse	Mule	Donkey	Poultry	Beehives
Agalo Meti	4,407	1,584	11,981	-	25	585	21,904	11,737
Yaso	9,871	2,680	7,131	-	40	576	22,141	6,838
Dibate	57,395	6,045	15,147	-	114	2,385	79,006	14,039
Bulen	30,511	5,794	3,312	-	17	1,884	60,611	13,063
Wonbera	43,194	9,054	14,787	530	333	4,655	67,739	16,636
Wonberma	60,286	14,515	5,810	62	6,915	144	-	4,213
Guangua	NA	NA	NA	NA	NA	NA	NA	NA
Total	**414,625**	**63,049**	**82,224**	**3,166**	**9,768**	**23,832**	**308,919**	**66,526**

Source: Regional offices.

Animal disease is prevalent in the affected woredas and an insufficient number of veterinary services and medicines makes the situation worse. Livestock diseases have imposed negative impacts on productivity of herds.

Major effects of animal diseases in the project area are cited as loss of weight, reduced growth, poor fertility performance, decrease in physical power and animal mortality (Socio-economic Characteristics of EN Basin Ethiopia, 2006). Livestock diseases are more severe in Benishangul Gumuz project woredas than in Amhara (78% of cattle diseased, and 60% died - according to the CSA 2003 report).

The most critical problems affecting livestock development in Benishangul Gumuz are cited as killer livestock diseases of all types (especially trypanosomiasis), shortage of water and feed during dry seasons, poor livestock husbandry practices and other related factors. The indigenous people are especially weak in managing the available feed[2].

A veterinary survey was conducted in Benishangul Gumuz in June 2004. It found that the mean herd incidence of trypanosomiasis in the year 2003 was 33%, and that the mean herd mortality due to the same disease during the same year was 22%.

Livestock disease is leading the households to extreme poverty/vulnerability as indicated by the survey. Other results of the study are summarized below:

- The direct mortality of animals is estimated to be in the order of 46% of the cattle herd and 38% of the sheep and goat flocks per annum respectively,
- The losses in live weight due to disease morbidity and numerous factors have chronic debilitating effects on livestock,

- [2] Ethno-veterinary survey, June 2004

- Trypanosomiasis reduces the quantity and quality of animal products such as meat, hides and skins. The cumulative effect resulted in economic losses that were greater than those suffered from mortality from all causes, including the widespread distribution of trypanosomiasis, biting flies, ticks and liver fluke infestations. The large extent of tsetse-infested areas is most significant.

Field investigation and discussions with communities in the project area showed that the effects of animal diseases are further exacerbated by the shortage of veterinary services including veterinary personnel, drugs, vaccines, and equipment for the prevention and control of animal diseases.

Investment

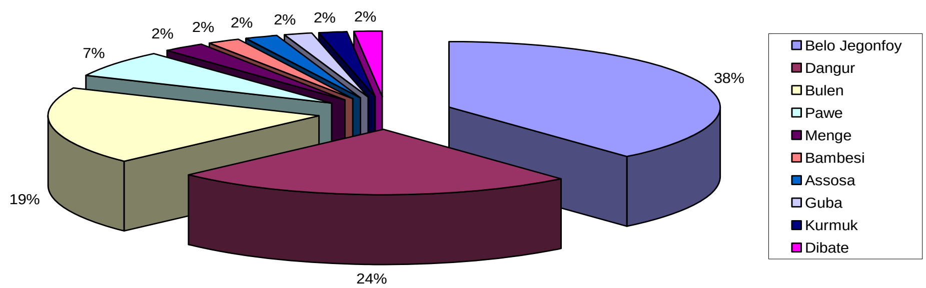
The investment situation in Amhara region is much better than in Benishangul Gumuz region. In Amhara, 768 projects with a capital of ETB 7.27 billion were in hand by 2005, creating 134,660 jobs (BoFED, Development Indicator Amhara region, 2005). Agriculture takes about 28 % of the total investment volume.

According to the discussion with experts of BoFED of Benishangul Gumuz, and reports obtained from the same source, the Investment Bureau of Benishangul-Gumuz issued a total of 61 investment licences in the region during the period 1994 - 2001. 26 of the licensed projects have subsequently been cancelled due to inability to operate. By February 2001, 23 projects with a total investment of ETB 245 million have been operational, and 12 projects with an investment of ETB 154 million were in the pre-operational (pre-implementation) phase. The investment projects operating during the reporting period created 767 permanent and 8,164 temporary job opportunities, whereas the projects under implementation will create 427 permanent and 1,193 temporary jobs.

Agriculture and agro-industries together take the lion share of the investments in Benishangul-Gumuz (including incense and gum). The sector accounts for 86% of the operational and pre-operational projects and 97 % of the investment volume.

With regard to distribution by woredas, Belo Jegonfoy has nine projects, Asosa seven projects, Dangur six projects and Pawe four projects. The Mandaya project woredas have the lowest investment projects. Two investors have started operating in Guba and Sirba Abbay woredas currently but are not very significant.

The distribution of the investment among the woredas is shown in Figure 4.14. As may be noted, investment in Wonbera, Yaso and Agalo Meti is so low that these woredas are not included in the chart.



Source: Compiled from Data obtained from BoFED of Benishangul Region

Figure 4.14 : Investment Distribution in Benishangul Gumuz

Investment is highly encouraged in the project area. In order to attract the private sector to engage in the development of the existing potential resources in the area, the regional governments have tried to attract investors by providing various incentive mechanisms including reducing the process of land requisition to handover to take only 30 days, providing free urban land; land tax free for five years; income tax free for five years, and tax free importation of agricultural equipments.

Industry, manufacturing and craft works

Medium or heavy industry does not exist in any form in the project area. However, small-scale industries exist in town craft shops such as carpenters' workshops, bakeries, bamboo processing workshops and others. Grinding mills have been constructed in towns as well as in rural areas during recent years. They give service to the local population.

Fishing

The Abbay river and tributaries in the project area are suitable for fishing but the fishery potential of them is not properly known. Local people and authorities reported that there are some individuals who practise fishing, mainly for their own consumption.

The traditional practice of fishing is somewhat different from most places in the country. A stick (rod) and hook is left without attendance, sometimes over night.

People take fresh fish to some market areas to sell them. Sold fish is normally cooked and consumed by people doing business in the market. Buying fish from the market for home supply is not a common practice in the area. Fish do not have commercial value, but in rare cases some fishermen take dried (smoked) fish to nearby towns for sale (Plate7).

Plate 7: Fish caught near Mandaya dam site. ENTRO survey boat in background, April 2007

Mining

The existence of gold and gold mining is long known in the Benishangul Gumuz region. Historical records state that a concession was given to one British mining company in January 1900 by Emperor Menelik II (BoFED, General Economic Characteristics of Benishangul Gumuz, 2003).

Currently, traditional gold mining (by panning) is widespread in Benishangul Gumuz region in general, but very limited in the Mandaya project affected woredas. The survey team could not confirm any gold extraction activities in Mandaya woredas. (Plate 8).

BoFed of Benishangul Gumuz estimates the current traditional gold miners to be about 50,000 people and extraction of 180 kg gold per year on average. (These figures have not been substantiated for this study). The areas of activity are mainly downstream of Mandaya. Gold panning is among the seasonal activities in the Border project area, particularly along Abbay, Beles and Dabus rivers. It is reported that gold panning is carried out along the Abbay river by almost all woreda people adjacent to the river and that almost all able adults including men and women are engaged in this for at least three months a year (during low flows). The amount of gold extracted is reported to be small in quantity in general, depending on luck rather than hard labour. Some confirmed extracting a couple of kilos (rarely) and many reported only small amounts. Whatever the amount collected, gold panning is a source of income generating activity that helps to support families to buy non-farm commodities (e.g. clothes, salt, sugar).

Currently two private companies have licences and are operational in exploration and exploitation of gold and base metals (Guba, Dibate and Bulen woredas).

Marble is extracted by private sector investors and by the Federal Government's *Marble Industry of Ethiopia*. Dibate, Bulen, Guba and Yaso woredas have marble quarry sites in the project affected area but not, so far as could be ascertained, in the potential impoundment or other construction areas.

Plate 8 : Traditional gold panning downstream of project area

Hunting

As everywhere in the nation, hunting is illegal unless one has a licence to hunt. There is a controlled hunting area in the lower Dabus valley (downstream of Mandaya) but no information was made available about it. The Dabus valley controlled hunting area is a tentative candidate to become designated as an Important Bird Area of Ethiopia but a decision on promoting this has been deferred until such time as surveys are conducted and a proper assessment is made.

Although the woreda authorities cautiously indicate that hunting is not exercised in the project area, they mentioned that there might be a few people hunting illegally. According to consultations with local people, however, hunting is known to be a traditional and cultural practice in the area. Individuals hunt antelope, porcupine, monkeys and other animals for food. Hunting among the Gumuz has social esteem where hunters occupy high status in the community. Hunting is done using spears and arrows. Moreover, there is a traditional hunting ceremony known as Feda among the Bertas (noted in a report compiled by BoFED of Benishangul Gumuz).

Trade and other services

Trade activities in Amhara are generally exercised, but to a lesser extent in Benishangul Gumuz Region. There is no well organized market structure and market places except in few places in Benishangul Gumuz. On the other hand, in Amhara project woredas' markets seem better organized.

There are limited commercial service providers in the project woredas. Hotels and restaurants exist in the Mandaya project area but provision is weak in general. There are tea rooms and small restaurant in all larger settlements of project area (Table 4.21).

Table 4.21: Services in Mandaya project area woredas

No.	Woreda	No of Police Stations	Tourism Sites	No of Hotels	No. of Restaurants	No of Tea/ Coffee Rooms
1	Agalo Meti	1	0	0	1	1
2	Yaso	1	0	1	1	1
3	Dibate	1	0	1	1	3
4	Bulen	1	0	3	2	4
5	Wonbera	1	0	2	2	4
6	Wonberma	1	0	2	3	3
7	Guangua	1	0	4	4	4
	Total	**7**	**0**	**13**	**14**	**20**

Employment and Income Generation

The majority of people (over 90%) in the reservoir area obtain their livelihood from subsistence agriculture. Agriculture practices included farming and livestock. Small numbers of people are engaged in trade, in government organizations and other activities. Generally the incomes generated from these activities are very small. The incomes are insufficient to cover even basic necessities hence they live in poverty with the exception of Wonberma in Amhara Region where per capita income is reported to be USD 780 per year - much higher than the national average.

A large number of the farmers and urban dwellers in Benishangul Gumuz (men and women) woredas are also engaged in gold panning. Many people in the woredas go to the Abbay River channel to extract gold traditionally, especially in the months of January to April.

In general, the project affected area has very high untapped potential of natural resources that could be utilized for income generation. However, the contribution of the resources for the well-being of the society, so far, is minimal. The income obtained by people is barely sufficient for survival and inadequate to improve the life style of the inhabitants. Most households in the project area generate their cash need from other sources, such as by selling crops and livestock. Gold extraction is also an activity as additional income for the people who are characterized by poverty.

A study conducted by Benishangul Gumuz government1 shows that per capita income obtained from the sale of agricultural produce and other non-farm income is from ETB 169 (Guba) to ETB 537 (Sirba Abbay). In Amhara, the figure is higher (compare Wonberma with ETB 6,786 per person per year).

Major constraints of the people to generate sufficient income for their needs are reported to be lack of appropriate technologies, lack of awareness and inadequate skills; poor market infrastructure that is made worse by the poor all-weather road network, as well as unorganised market places and low private investment.

Unemployment in the project area is said to be lower than other places in the nation, about 5% in Benishangul Gumuz and 8% in Amhara. Rural unemployment is 4% and 6% for Benishangul and Amhara respectively2.

Persistent poverty is therefore due to low income (55% of the people of Benishangul Gumuz are under food poverty line). In Oromia it is 6%, and in Amhara it goes up to 8% (CSA, for 1999).

Poverty and Food Security

As discussed above, poverty in the project area is prevalent. Both men and women work on the farm and off farm but the income they earn is very meagre to satisfy their needs. Backward farming system, failure of rainfall, pests and time consuming labour (such as gold panning) contribute to this. Chronic poverty is evident by the fact that a large number of people in the project area have to rely on relief assistance.

A report (Food Security Strategy, 2004) describes the nutrition status of people in Benishangul Gumuz Region. Low nutrition, protein-energy deficiency as well as nutrition and micronutrient deficiency are widespread in most places of Benishangul Gumuz including the project area. Chronic malnutrition (shunting), acute malnutrition (wasting) and underweight (for age) are very high in Benishangul Gumuz, particularly among the indigenous people of the region. The report concludes that the Benishangul part of project area is one of food insecure places in the region. The Amhara portion is better placed.

- [1] Food Security Strategy, June 2004
- [2] The definition of unemployment in Ethiopia is modified version of the unemployment set by ILO. The unemployment measure of CSA takes into account the prevailing economic condition of the country (CSA Analytical Report on the 1999 National Labour Force Survey, Addis Ababa, 2000).

4.3.5 Social services

Education

The educational status in the Mandaya project area is considered low by many studies conducted in the regions. The primary enrolment rate in Benishangul Gumuz woredas is generally better but the problem is the high drop out rate. The enrolment rate is in favour of boys in the region.

Tradition is often cited for low level of girls' enrolment compared to boys. This is true among the Gumuz ethnic group in particular. Young women are required as exchange marriage and most of farm work, and all household work, is loaded on them. Other reasons for the low level of female enrolment are distance from school and poverty.

As may be deduced from Table 4.22 the number of girls in school in the project area is only about 40% of the total student population. Also, the number of female teachers is similarly lower than the number of male teachers.

Table 4.22: Education in Mandaya project woredas

Woreda	No of Schools	No. of Teachers			No. Students		
		Male	Female	Total	Male	Female	Total
Agalo Meti	15	80	37	117	3,073	1,936	5,009
Yaso	10	76	7	83	1,302	694	1,996
Dibate	23	174	69	243	7,398	5,271	12,669
Bulen	12	110	43	153	4,900	3,232	8,132
Wonbera	24	174	85	259	5,873	4,264	10,137
Guangua							
Wonberma							
Total	**84**	**731**	**281**	**1,012**	**26,683**	**18,575**	**45,258**

Taking Benishangul Gumuz region as a whole, girls' school enrolments is generally less than boys across the ethnic groups of the region, and the degree of girls' participation varies from one ethnic group to another (Table 4.23. Overall girls' enrolment is 36% of total. The Gumuz girls' enrolment is only 25% of total.

Among the Berta it is 30%, Shinasha 36% while the figures for Amhara, Agew and Oromo are relatively better than other ethnic groups but still less than the boys.

Table 4.23: Gender proportion in school attendance in Benishangul Gumuz

Ethnic group	Gender Proportion				
	Male	Female	Total	Male %	Female %
Amhara	1,524	1,314	2,838	54	46
Berta	2,430	1,053	3,483	70	30
Gumuz	2294	783	3,077	75	25
Shinasha	1392	787	2,179	64	36
Oromo	1214	741	1,955	62	38
Agew	300	250	550	55	45
Mao	337	121	458	74	26
Others	210	140	350	60	40
Total	**9,701**	**5,189**	**14,890**	**65**	**35**

Source: Bureau of Education, Benishangul Gumuz, 2004

Public Health

A preliminary assessment of public health was made by the consultant with the objectives of assessing health service status of project affected woredas, identifying potential diseases related to hydropower scheme implementation and suggesting possible mitigation measures.

Housing

Overall, the quality of houses is poor and affects negatively the health of inhabitants.

In addition, houses are often without windows and chimneys and cannot avoid smoke. This is, perhaps, the chief reason for widespread respiratory tract and eye infections in the project area[3].

The Burden of Diseases

Review of records available at woreda offices of health reveals that the burden of disease, as measured by premature deaths of all causes, emanates primarily from causes preventable by simple public health measures. Communicable diseases and diseases resulting from malnutrition predominate.

The main factors responsible for the burden of ill health include inadequate access to health services; poor access to clean drinking water and sanitation facilities; widespread poverty and ignorance. Access, in this case, includes not only scarcity of health facilities but also distances and physical barriers. Women and children bear the brunt, chiefly due to their physiological make-up and the low social status accorded to them.

The major diseases in the project-affected areas include upper respiratory tract infections (URTI), malaria, diarrhoea and skin infections. Table 4.24 summarises the leading diseases treated in the Benishangul part of the project area. The patterns of

- [3] Lulu Muhe, Eth. J. H.D, 1997

disease are very similar in all project woredas, although there are slight variations in magnitude. There is similarity in disease prevalence and types in the Amhara part of the project area.

Table 4.24: Top 10 leading diseases in Mandaya area woredas

Type of disease	Cases No.	Cases %
Malaria	186,432	40
Bronchitis	88,345	19
Gastric	66,368	14
Intestinal Parasites	46,248	10
Dysentery	26,876	6
Unknown	18,448	4
Rheumatism	14,722	3
Skin diseases	12,786	3
Eye diseases	1,560	<1
TB	467	<1
Total	**462,657**	**99**

Reviews of monthly and annuals reports from all health facilities reveal that malaria is the single most important public health problem in the project woredas. It accounts for more than 50% of morbidities and mortalities in all health facilities in the project area taken as whole. The chief reasons for the widespread occurrence of malaria include lack of environmental management to destroy mosquito breeding sites at community levels, unavailability of insecticide-treated mosquito nets (ITN), resistance of malaria parasites to most drugs currently on the market, and resistance of mosquitoes to insecticides.

HIV/AIDS is a new disease emerging in the area. Although there is no consolidated data, an in-depth interview with relevant officials showed that the disease is prevalent and on the rise. According to the same informants, the disease is being imported into the area with immigration of girls and young ladies from adjacent and outlying highland areas.

The dominant water-borne and water-related diseases include Schistosomiasis, Malaria, Onchocerciasis and Trypanosomiasis (human sleeping sickness). Others include acute watery and bloody diarrhoeas, intestinal parasites, scabies, etc; these are rampant in the project area due to unacceptably poor water supplies and absence of basic sanitation facilities.

<u>Health Facilities and their Ratios to the Population</u>

Access to and quality of health care is an important indicator for the socio-economic well being of a society. The current policy of the Federal Ministry of Health recommends one health post for every 5,000 population, one health centre for every 25,000 people and one hospital for a population of 250,000. However, data obtained from woredas' offices of health indicates an overall health facility to population ratio of 1: 12,600. This is a very low ratio even by the standards of Sub-Saharan African countries.

The number and types of primary health facilities available are shown in Table 4.25 There is no hospital in the project woredas. In most project woredas, patients who may need a higher health care have to travel a minimum distance of more than 150 km.

By and large, the number of health facilities existing in the project area is far from being adequate to meet the demands of the population. In addition, they are severely under-staffed, ill equipped and under-supplied. The existing health facilities are built by Government in collaboration with communities, NGOs and multilateral organizations.

Table 4.25: Health facilities available in the Mandaya project woredas

Woreda	Governmental			Non-govern-mental	Non-functional HF, HF under construction
	Hospital	Health centre	Health post / health station		
Agalo Meti	0	0	2	1 (missionary)	
Yaso	0	0	2	1 (missionary)	
Dibate	0	1	4	0	2 HP
Bulen	0	1	2	0	2 HP
Wonbera	0	1	1	0	2 HP
Guangua	NA	NA	NA	NA	NA
Wonberma					
Total	**0**	**3**	**11**	**0**	**6 HP**

<u>Harmful Traditional Practices</u>

Harmful traditional practices (HTP) are rife and deep rooted in the project areas. The most common forms of HTP include the following:

Kumsangilla: This is a practice in which a Gumuz woman gives birth in a bush unassisted. According to the focal group discussion in Yaso and Wonbera woredas, almost all women used to give birth unassisted in bushes about 250 – 350 metres away from their homes. This is simply due to misconception that if a woman delivers at home, family members of the household in which a woman gives birth will be afflicted with a disease that, in their own words, ‘mutilates or causes general swelling of the body” - possibly leprosy or liver cirrhosis from the descriptions, respectively. Some also perceive that a child born in that particular household will not grow up to adult age. The practice is an age-old one that has pervaded the entire fabric of the community. This practice is, however, fading away currently and many people are abandoning the tradition.

Female Genital Cutting/Mutilation(FGC/M)**:** Although reportedly on the decline, FGC/M continues to be practised in the project woredas. The type of FGC commonly practiced is 'Excision', sometimes called Type I, more common in Amhara and Oromia. It is simply the removal of clitoral hood. Severe forms of FGC, such as infibulations, are performed in Benishangul region. The reasons for practising FGC/M, according to our focus group discussions, are to 'avoid sexiness' and to conform to the community.

Early Marriage**:** Early marriage is also a widely practised tradition in all project woredas. Families marry off their daughters early because families want to gain material benefits and to maintain the chastity of their daughters. Also, families feel obliged to reciprocate the wedding ceremony they attended (especially among Amhara people) in the community.

Swinging of Women during Labour**:** This is a practice whereby a woman in labour is swung in order to expel the products of pregnancies. It is a harmful traditional practice that may cause rupture of the uterus, eventually leading to death.

Women's workload

Women often have a heavier workload in comparison to men. Work often involves heavy physical weight-bearing activities and other activities that can be risky to health. In addition women, as is in many parts of Ethiopia, have high birth rates (on average 7 children/woman) and thus spend much of their adult lives either pregnant or breastfeeding, a phenomenon that alone can take a heavy toll on a woman's health and well being.

When coupled with other common health concerns, such as poor nutrition and limited access to health care, a woman's daily workload may have an important impact on her health or the health of her children – unborn or born. Understanding the possible relationship between women's daily workload, nutrition and health care and care of their children is important not only to improve the health status of mothers and children but also to the overall goal of developing their communities in particular, and the region in general.

Water and Sanitation

Safe and adequate water supply and sanitation facilities are important indicators for the socio-economic status of a country. However, provisions of these facilities are either unacceptably low or absent in most parts of the project affected areas. In particular, basic sanitation facilities for solid and liquid waste disposal are virtually non-existent. According to focus group discussions and in-depth interviews, bushes around homesteads are sites where people defecate. This is undoubtedly the main reason for high prevalence of diarrhoea diseases and other intestinal parasites in the project areas as described earlier.

Water sources for the majority of households are rivers and ponds. These sources are contaminated and unsafe. People travel on average 8 to 10 km to fetch water. Fetching water is considered the responsibility of women and young girls. Overall, it is estimated that only 27% of people in Benishangul and 28% in Amhara have access to potable water. Water supply schemes involving shallow wells, hand dug wells, deep wells and springs are summarized in Table 4.26

Table 4.26: Water Supply Facilities by Woreda in Mandaya Project Area

Woreda	Type of Schemes			
	Shallow well	**Hand Dug Well**	**Deep Well**	**Spring**
Agalo Meti	0	10	0	3
Yaso	0	0	0	0
Dibate	8	66	2	32
Bulen	16	3	3	2
Wonbera	6	12	1	2
Wonberma				
Guangua				
Total	**30**	**91**	**6**	**39**

Source: Regional Water, Mines and Energy Resources Bureaus

Water provision in Benishangul Gumuz is done by carrying several containers full of water suspended at two ends of a rod put on the shoulder (Plate 9). The total weight carried by the lady is estimated at about 75 kg.

Sanitation facilities in the project woredas are among the poorest in Ethiopia. Most people do not have sanitation facilities of any kind. About 80% of people in Benishangul Gumuz region do not have toilet facility; conditions are worse in the project area.

With regard to sanitary facilities, the proportion of people with basic sanitation facilities is much lower. 66% of the people in Benishangul and 87% in Amhara use field or forest to defecate; 33% in Benishangul and 11% in Amhara have pit latrines. The number of flush toilets in the project area is non-existent.

Plate 9 : Water Provision in the Mandaya Project Area

Cultural Setting

The cultural setting of the people living in the area has positive and negative effects on the development of the area and the project. The positive sides of their culture are their strong social bonds and sense of togetherness during holidays and feasts - Idir, Iqub and Feda culture in the project area (Plates 10 and 11).

Major negative impacts of cultural practices are the business culture and working behaviour of the people in Benishangul Gumuz. The business culture in the Amhara project woredas is much better than in Benishangul Gumuz. The tradition regarding women is also negative.

On the hand, there are different cultural practices that affect women and their contribution to development. The main cultural practices that affect development in the region are Kumsangilla, female genital mutilation and early marriage.

Many holidays and ceremonies are affecting the working culture negatively. Although women are also victims of such cultures, men are most affected by such traditions.

Other features such as scars on the face and avoidance of certain kinds of food as cultural taboos (e.g. many Gumuz do not eat milk and eggs) are examples of negative aspects of the cultural setting.

Plate 10: Traditional Dance of Gumuz in the project area

Plate 11: Social Gathering in the project area

Market Places

There are no well-structured and organized market places in the Mandaya project area. There are, however, informal transactions of trade and some organized market places in very limited areas (Plate 12). In Amhara project woredas, a better structure and more commodities are observed.

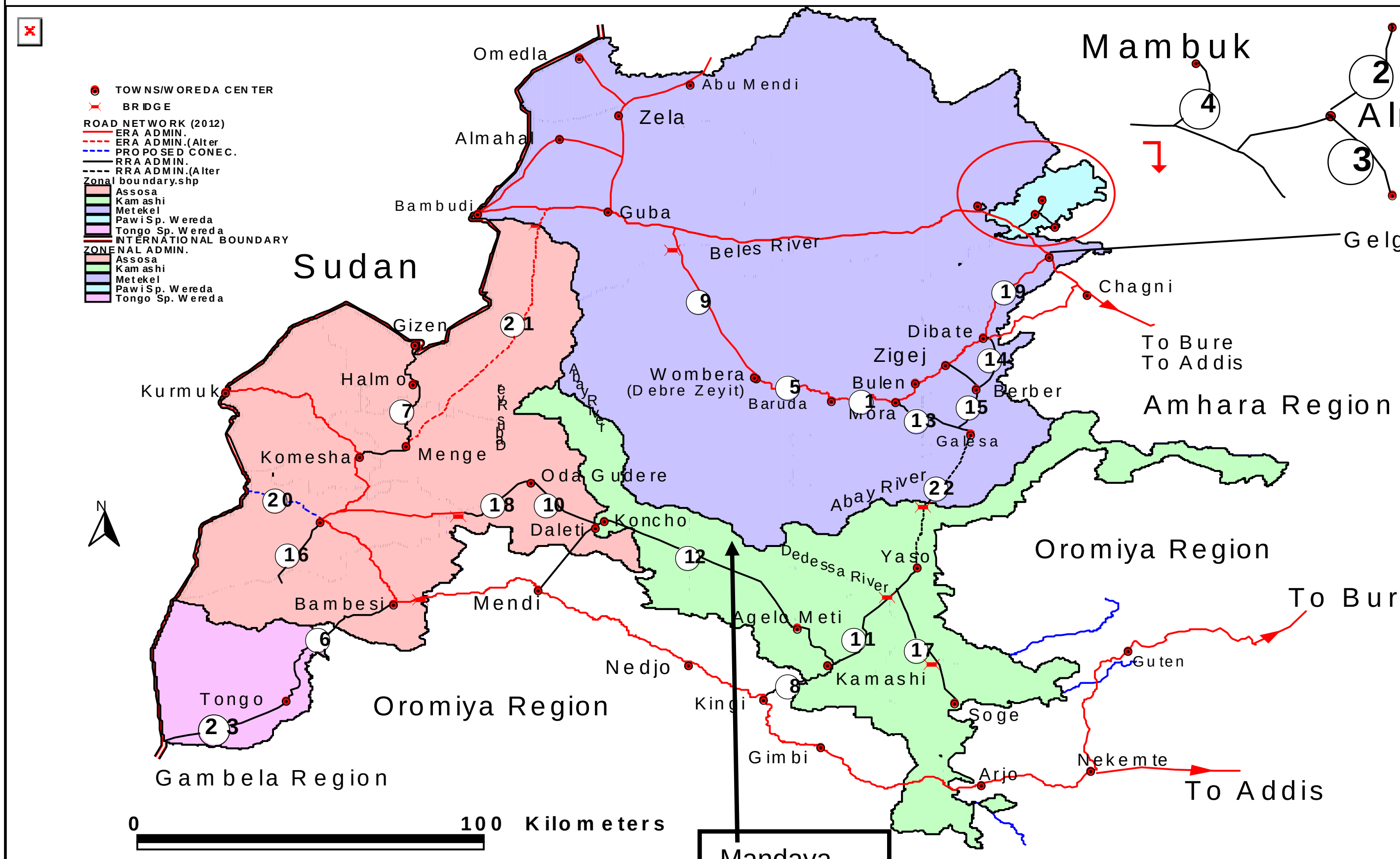
Plate 12 : Gold Market in Benishangul Gumuz

4.3.6 Infrastructure

Road and Transport

The road infrastructure in and around the Mandaya project area is one of the poorest in the country and hence travelling from one place to another is difficult and expensive. Even transportation by pack animal is reported to be very expensive.

The total existing road network in Benishangul Gumuz is 719 km according to a compilation of GIS & RIS (BoFED, Dec. 2003). Out of this, 454 km are all-weather roads and 278 km of all-weather roads are under construction. In Amhara, there is a better road network compared to Benishangul Gumuz, but none in the Mandaya reservoir area (Figure 4.15).



Road Name	Road No.
Dibate-Baruda	1
M/Road-Ali Spring	2
Pawe(Almu)-Diga	3
M/Road-Mambuk	4
Baruda-Wombera	5
Bambasi-Tongo	6
Komosha-Gizen	7
Kingi-Kamashi	8
Guba-Wombera	9
Daleti-Oda Gudere	10
Kamashi-Yaso	11
Daleti-Kamashi	12
Mora-Galesa	13
Dibate-Berber	14
Zigej-Galesa	15
Asosa-Sherkole-Enge	16
Yaso-Soge	17
Undalo-Oda Gudere	18
Dibate-Gelgel Beles	19
Asosa-Koshemenged	20
Asosa Guba	21
Yaso-Galesa	22
Tongo-Yayu	23

Source: Benishangul Gumuz Road Authority

Figure 4.15: Existing and Future Road Network in Benishangul

Donkeys are used as means of transport for humans, animals and goods (Plate 13).

Plate 13: Goods and Passenger Transportation around Mandaya Site

River Crossing Routes

People cross the Abbay river for trade, visiting relatives, health services and other personal reasons.

They use traditional boats for these purposes and pay about ETB 5 for a single trip per person. For livestock, the charge is about ETB 20 per animal per single trip. There are one or two crossing routes along the river in the potential Mandaya reservoir area (Plate 14).

Plate 14: Mode of Transport (Feluco) on Abbay River

Telecommunications

The Mandaya project area does not have postal or telecommunication services. To date, the only places with these services are Asosa and Pawe towns. According to CSA's 1994 census information, only 1.7% of all urban and 0.14% of all Benishangul Gumuz households have telephone facilities. There is no figure for current status. Even though very low, there are better telecommunication services in Amhara parts.

Currently there is no reception of mobile telephone in the Mandaya reservoir area. There is a plan to connect all woredas in the nation with telephone lines using Broadband.

4.3.7 Energy

The principal energy source of the region is fuel wood (Plates 15 and 16). Cooking is the major end use and a large number of people use fuel wood for lighting. 97% of energy consumed in 2004 came from wood, 2% from agricultural residues and the remaining from modern fuels (Benishangul Gumuz Profile, BoFED, 2005).

in Amhara, in addition to fuel wood, people use dung and BLT (Branches, Leaves and Twigs). Cooking is major use of fuel wood but kerosene is used for lighting in the Amhara part of the project area. About 72% of energy in Amhara comes from biomass fuel. 40% of light energy comes from kerosene.

Plate 15: Fuel Wood Collection in Yaso

Plate 16 : Charcoal Market

4.3.8 Resettlement Efforts

The dispersed pattern of settlements has adversely affected the development of infrastructure, public facilities and the overall socio-economic development of the area. To improve this Benishangul regional government has conducted a study of appropriate establishment of settlement centres with a view to improving the people's way of life. Accordingly, a total of 41 resettlement villages have been identified and made ready for resettlement in the following woredas: Kamashi, Yaso, Agalo Meti, Belo Jagenfoy and Sirba Abbay.

The woreda authorities advised that there are a number of sites in the project woredas that are suitable for resettlement and that a list of these can be obtained in future.

Our estimate of the numbers of households that would be directly and indirectly affected by the dam construction and reservoir components of the Mandaya project is 599, of which 120 households (600 people) would be affected by reservoir impoundment.

4.3.9 Sites of Religious, Historical or Archaeological Importance

Review of archaeological literature and study documents by the consultant's archaeologist revealed no archaeological or historical sites in the Mandaya reservoir or works areas.

This is not to say that archaeological or historical sites do not exist in the Mandaya project area, only to say that the project area has not been extensively surveyed in the past, other areas in the Nile valley, including the well known ones in Sudan and Egypt, taking precedence.

Archaeological research near the project area was conducted in Benishangul Gumuz between the Abbay and the Sudanese border in 1992 E.C. by an archaeological team from University Complutense of Madrid. This research recorded artefacts, flakes, isolated lithic core tools in dark green volcanic rock (choppers and chopping tools, picks core scrapers hand axes and so on) between the Abbay river and Boka river. These features were categorized as Early and Middle Stone Age.

During an archaeological research survey in 2001-2003, two rock shelters with red schematic paintings were discovered near the village of Menge, the administrative centre of Menge woreda, situated approximately 50 km north of Assosa and 40 km west of the Abbay river (Figure 4.16). The two rock shelters with red schematic paintings are at Bel Bembesh and Bela Sharasu. Evidence from the pottery sequence, radiocarbon dates and historical data suggests that the rock paintings probably date to the 16th or 17th century AD and may be related to the arrival from Sudan of the Berta people. Local informants and researchers have offered a variety of explanations for the paintings. Some suggest they might have been connected to rain-making rituals while others do not. Rock art nevertheless enhances the value of the sites to modern people even when they were not responsible for its production (Fernández and Fraguas, 2004)

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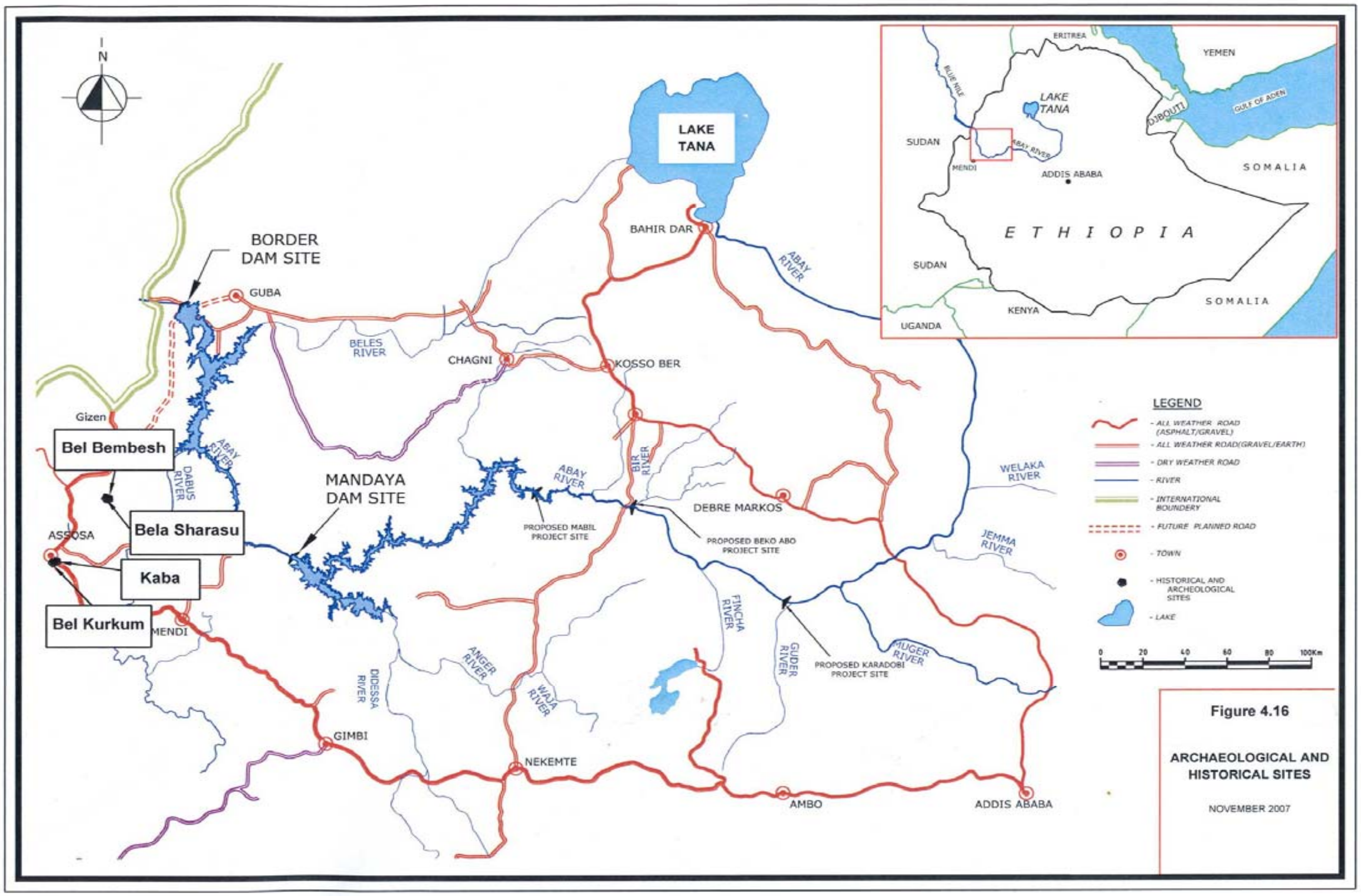
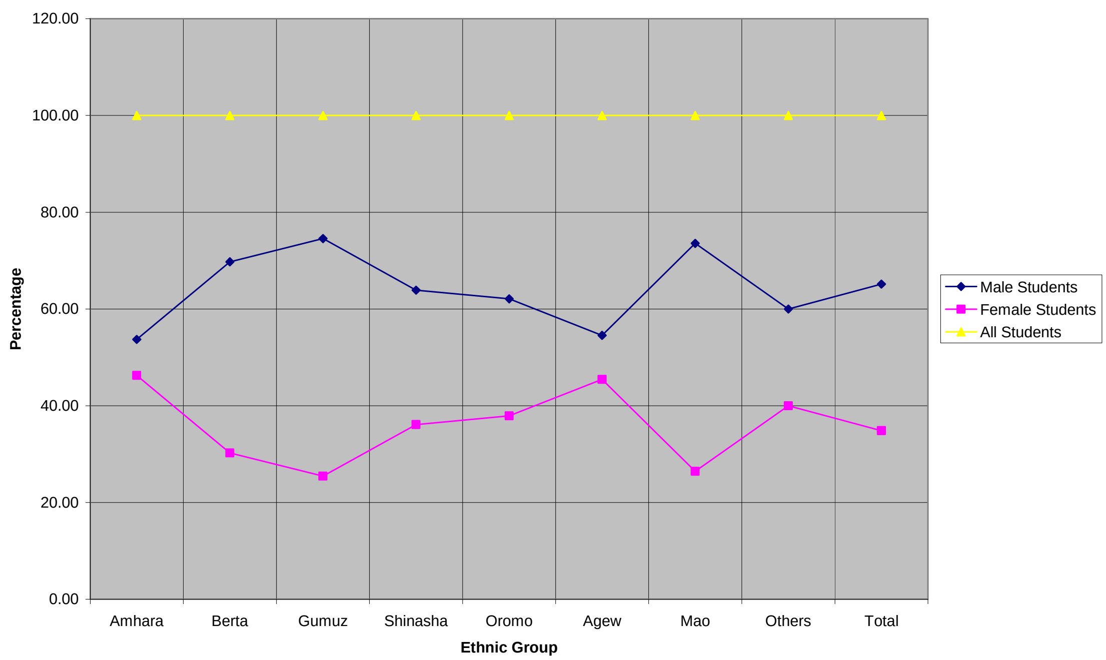

N
LAKE TANA
BAHIR DAR
BORDER DAM SITE
GUBA
BELES RIVER
CHAGNI
KOSSO BER
ABAY RIVER
BIR RIVER
Gizen
Bel Bembesh
DABUS RIVER
MANDAYA DAM SITE
PROPOSED MABIL PROJECT SITE
PROPOSED BEKO ABO PROJECT SITE
DEBRE MARKOS
WELAKA RIVER
JEMMA RIVER
ASSOSA
Bela Sharasu
Kaba
Bel Kurkum
MENDI
FINCHA RIVER
GUDER RIVER
PROPOSED KARADOBI PROJECT SITE
MUGER RIVER
ANGER RIVER
DIDESSA RIVER
WAJA RIVER
GIMBI
NEKEMTE
AMBO
ADDIS ABABA
ERITREA
YEMEN
LAKE TANA
DJIBOUTI
GULF OF ADEN
SUDAN
ADDIS ABABA
SOMALIA
E T H I O P I A
KENYA
UGANDA
LEGEND
- ALL WEATHER ROAD (ASPHALT/GRAVEL)
- ALL WEATHER ROAD(GRAVEL/EARTH)
- DRY WEATHER ROAD
- RIVER
- INTERNATIONAL BOUNDERY
- FUTURE PLANNED ROAD
- TOWN
- HISTORICAL AND ARCHEOLOGICAL SITES
- LAKE
0 20 40 60 80 100Km
Figure 4.16
ARCHAEOLOGICAL AND HISTORICAL SITES
NOVEMBER 2007

These known sites will not be influenced by the dam or reservoir project but their existence draws attention to the need for further consideration to be given to sites of religious, historical and archaeological importance during project feasibility studies, including locations of transmission line towers.

4.3.10 Gender Conditions in Benishangul Gumuz Region

As already described, women in the project area are a marginalized part of society in the three regions. Women are not given sufficient attention and are not fairly treated in communities. They are required to contribute higher workloads than men in cultivation. They are also responsible for all works in the household including child rearing.

Women have no equal decision making powers on the wealth of the household and have, with some exceptions, no access to improved technologies, including health services. Girls' school enrolments are generally less than boys in the region as seen in Figure 4.17. Educational disparity between men and women is another indication of social injustice, considering education is the key to lifestyle and livelihood improvement. Moreover women and children are vulnerable to many kinds of harmful traditional practices and customs.



Source: Benishangul Gumuz Bureau of Education

Figure 4.17 : Gender disparities in school enrolment - Benishangul Gumuz

4.4 EXISTING INSTITUTIONAL CAPACITIES

Regarding human, financial and material capacities in Benishangul Gumuz and Amhara regions in general and the Mandaya project area in particular, it is found that the necessary capacities are not in place.

The major problems concerning implementation capacities of the region (as described in the strategic plan document prepared by BoFED, 2004) are:

- Lack of professional manpower to execute programs or projects,
- Insufficient capacity of development programs in the region,
- Lack of vehicles and equipment in all organizations related to the potential Mandaya project,
- Inadequate capacity of existing implementing organs and authorities,
- Lack of motivation,
- Unavailability of monitoring and evaluation systems in all the organizations of the region, and
- Chronic financial shortage.

This situation affects implementation and monitoring capacities of the tasks of any major project (such as the Mandaya project) that are the responsibility of the regional and woreda governments. Although there is better capacity in Amhara region, all of the above problems exist there also to some extent.

4.5 SECONDARY IMPACT ZONE IN ETHIOPIA

The physical, biological, socio-economic and cultural environments of the Mandaya project area's direct impact zone have been described in preceding sections. These conditions generally apply to the area extending downstream of Mandaya dam site along the Abbay river approximately 200 km to the Sudan border. This downstream area constitutes the secondary impact zone of the Mandaya project in Ethiopia. Existing environmental conditions downstream of the Ethiopian/Sudan border are described in Chapter 5.

The secondary impact zone of the project in Ethiopia relates to Abbay river itself, anticipating changes to the river's behaviour. The whole of this reach is under the administration of Benishangul Gumuz region and three woredas: Sirba Abbay on the left bank (west and south side) and Wonbera and Guba on the right bank (east then northern side). The socio-economic and cultural conditions of this area depend on uses of natural resources, as described for Mandaya, but there are three principal activities associated with the Abbay and its flows condition which require noting.

River Crossings

There are no bridges across the Abbay in this reach. Indeed the lowest vehicular crossing point on the Abbay in Ethiopia is at the extreme upstream end of Mandaya reservoir, where a bridge links Nekemte to Bure. Feluko boats are the normal means of crossing the river, as described above. Towards the end of the dry season, especially when the previous rainy season was poor and flows have receded to extremely low levels in the early months of the following year, there may be certain favourable places for people to cross by wading, with or without livestock.

The situation regarding a vehicular road bridge and feluko and pedestrian crossings of the Abbay will change with the Mandaya project.

Recession Agriculture

Field observations and consultations with local people indicated the practice of recession agriculture on both banks of the Abbay river in this reach. The cultivated areas depend on the Abbay flood during the high flow season (July, August, September). There is no available data on the extent of flood recession cultivation or the number of people using these moist areas. On-site observations, GPS marking and interpretation of air survey photographs (October 2006) indicated that the naturally flooded land area used for recession agriculture in the area could be in the order of 2,400 ha. The situation will change under river regulation conditions of the Mandaya project.

Gold Panning

Gold panning in the dry season is an important activity for many people in this reach of the Abbay river, and in tributaries. Reference to this has been made above. The situation will change under river regulation conditions of the Mandaya project.

4.6 PUBLIC PARTICIPATION

The socio-economic and environmental study carried out public consultations as part of field investigations and informed concerned people about the Mandaya project under study. The consultations consisted of focal group discussions, and discussions when collecting information about the localities. This included discussions on the culture, people and other socio-economic information with key informants and authorities in the context of exchanging views. The Consultant gave descriptions about the project, its benefits and the likely impacts on different groups of people. These were made known to a wide range of people, ranging from the presidents and vice presidents of Benishangul Gumuz, Oromia and Amhara regional states through to communities at different levels.

Discussions were held in the project area at every opportunity during field surveys and when collecting data in December 2006 and in visits made during January, February, March and April 2007. The objectives of the consultations were:

- to share with the people and authorities the concept of the Eastern Nile Power Trade Project;

- to obtain an understanding about the needs and priorities of the regions and the communities;
- to assess ongoing and any planned development projects in the proposed dam site and reservoir areas;
- to obtain feedback and reactions about the projects and project impacts from the participants of consultation sessions; and
- to assess and solicit the cooperation of governments and communities needed during the life of the project.

4.6.1 Public consultation

Public consultations were conducted at different levels starting from regional administration to local level organizations. Consultations with the regional administration heads focused on available information on the physical and natural environment in the project area, institutional set up and capabilities, existing and planned development and investment activities, settlement patterns and localities and other relevant environmental issues. In this respect, the Benishangul National Regional State President H.E. Ato Yaregal Aysheshum and other officials in the administration and sector offices were consulted in relation to the proposed project development (Appendix 4.9).

Local administration and sector officials indicated the absence of any investment or protected area in the proposed reservoir and surrounding area. However, the dense natural woodland vegetation is believed to be good habitat for a number of wildlife species that needs to be studied in the future. Settlement in the Mandaya valley is generally very limited due to the difficult terrain. Regional infrastructure and woreda capitals are located in the accessible upland areas. There is reported to be no problem related to relocation of the limited numbers of affected people in the proposed Mandaya reservoir and the local administration and relevant sector office will take the responsibility. It was further mentioned that the government has identified resettlement sites for a voluntary resettlement program. Some of the people to be relocated are those people that are repeatedly adversely affected by the Abbay river. Lack of finance for the establishment of basic infrastructure and facilities was found to be the main problem delaying the program. There is need to strengthen the various relevant sectors such as environmental protection, agriculture and rural development offices at different levels. Limited data and information about the Mandaya project area was indicated and the project study is believed to reduce the data gaps and assist offices that are engaged in various development interventions.

Discussions and consultations with key administration and sector officers are summarised as follows: -

- The project reservoir mainly falls in Benishangul, and extends a little into Amhara regional state.
- The general public service and infrastructure conditions in these woredas are very poor. There are the problems of lack of river bridges between woredas, poor road network and poor conditions of other infrastructure. The area is

covered with dense natural woodland having gorge and mountainous topography.

- Major economic activities in the project area include crop production, livestock rearing, gold panning (a minor activity), fishing and hunting. Fishing and gold panning are conducted using traditional methods.
- Market conditions are considered to be poor.
- Implementation capacities of sector offices for agriculture, natural resources, health, etc are at a low level. This is related to the topography, lack/high turn over of professionals, lack of equipment and weak financial position.

Focus group discussions were made at a number of places located in the reservoir and surrounding areas. A total of seven focus group discussions were held with people in the project reservoir and downstream areas that are engaged in different economic activities such as administration and sector offices representatives, farmers, traders and elders. The number of participants ranged from 10 to 32 and included both men and women (Appendix 4.10).

The main points raised during the discussion included the use of natural resources, traditional methods of crossing the Abbay and tributary rivers, major crops grown in the area, source of fuel, project's impact and associated benefit and other relevant topics.

The impoundment was found to be the main impact to the public since it affects settlements and agricultural areas. In this respect, the need to consult all affected people in the project area was stressed.

Discussions and consultations are summarised below: -

- Major source of energy is fuel wood; in most parts of the project reservoir area there is no practice of making charcoal for commercial purposes.
- Major economic activities in the project area include crop production, livestock rearing, gold panning, fishing and hunting. Fishing and gold panning are conducted using traditional methods.
- The reservoir inundation will directly affect not only those who lose houses and agricultural land but also those people who live outside the reservoir area because they will lose access to natural resources and other socio economic advantages, notably recession agriculture, gold panning, fishing, fruit from the baobab tree and other medicinal plants.
- Impediments to crossing the Abbay river for various purposes were mentioned.
- The need to provide relocation for affected farmers due to the reservoir, and compensation for other losses.

- The need to give priority for permanent and temporary job opportunities to people affected by the project implementation.
- Development of the project should consider improving social services and infrastructure conditions including electrification of main rural centres.

4.6.2 Public perception of project

Consultation with different groups of people during the field visits to the regions and project areas indicated that people of the region, and particularly those living in the potentially affected areas, expressed high interest in the hydropower project. All people rated the project as highly beneficial to the community, region and the nation. The reason for the high opinion of the project is that it will transform and improve social and economic conditions, and provide the much-needed infrastructure and linkages with the rest of the country, and links with power trading countries.

4.6.3 Authorities' Perception

The regional authorities also felt that the project will enhance development, reduce poverty and improve the well-being of communities. However, the relevant sector offices in Benishangul Gumuz region point out that they do not have the capacity to do their part in preparation for and follow-up of the implementation of a complex project like Mandaya hydropower project. Discussions and consultations with these organizations indicated top-most priority for a regional capacity building program.

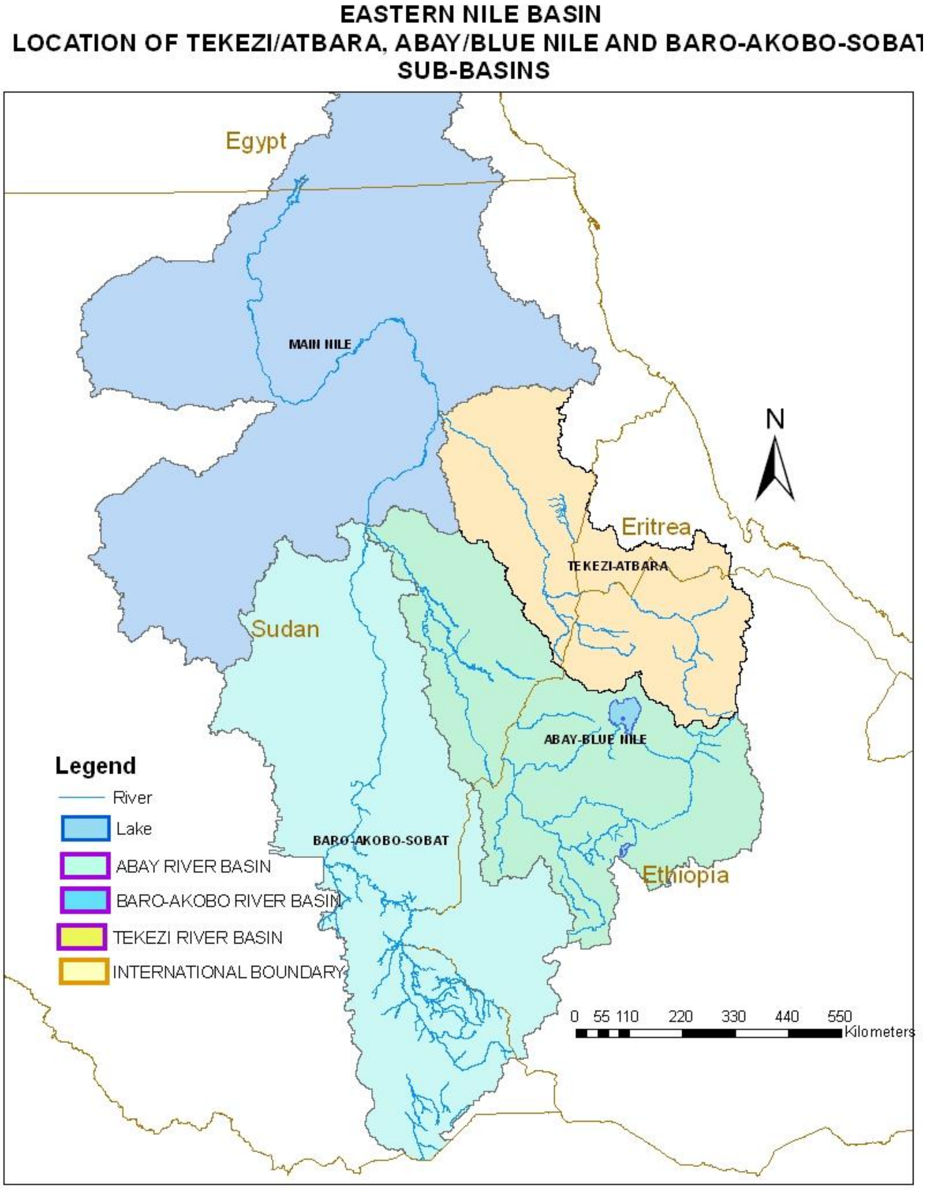
4.6.4 A Nurse's View

Because of the existence of a mission clinic at Boka, located on the left bank of Abbay downstream of Mandaya dam site, the views of a nurse on proposed hydropower developments were invited. This occurred by email communication following geological and ecological surveys based at Boka village in April 2007. The nurse, contacted in Norway, had been living among the Gumuz people from November 2001 until August 2005. She had learned the Gumuz language and had had contact with many people from different villages. Her views and concerns generally support the socio-economic, cultural and health situations described earlier in this section. They are recorded in Appendix 4.11.

5. EXISTING ENVIRONMENTAL CONDITIONS DOWNSTREAM OF MANDAYA PROJECT

5.1 INTRODUCTION

This chapter describes existing environmental conditions along the Blue Nile and Main Nile in their sub-basins in Sudan and Egypt, two of the four sub-basins of the Eastern Nile basin (Figure 5.1, Table 5.1) downstream of the Ethiopian/Sudan border.



Source: CRA Report, Sudan (2006)

Figure 5.1 : Eastern Nile Basin

Table 5.1 : Sub-basin areas within Sudan

Sub-basin	Area (km^2)	% area
Sobat/White Nile	390,860	33
Blue Nile	112,465	9
Atbara	109,208	9
Main Nile	582,368	49
TOTAL	**1,194,901**	100

Source: CRA Report, Sudan (2006)

For fuller accounts of biophysical and social conditions of the Blue Nile and Main Nile in Sudan, readers are referred to the principal source of the text - a report entitled: "Cooperative Regional Assessment (CRA) for Watershed Management – Transboundary Analysis, Country Report, Sudan", produced for the Nile Basin Initiative/ENTRO for its Eastern Nile Watershed Management Project (Hydrosult *et al*, September 2006).

The Transboundary Analysis report comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the sub-basins, and to identify opportunities and benefits of cooperation in watershed management. It is proposed that the results of the analyses of the sectoral CRAs will be brought together in the design and decisions in a joint multi purpose programme (JMP) of interventions (Figure 5.2). The general elements of a CRA are (i) institutional strengthening, (ii) a participatory process for building trust and confidence, and (iii) to gain a transboundary understanding the watershed system from a basin wide perspective.

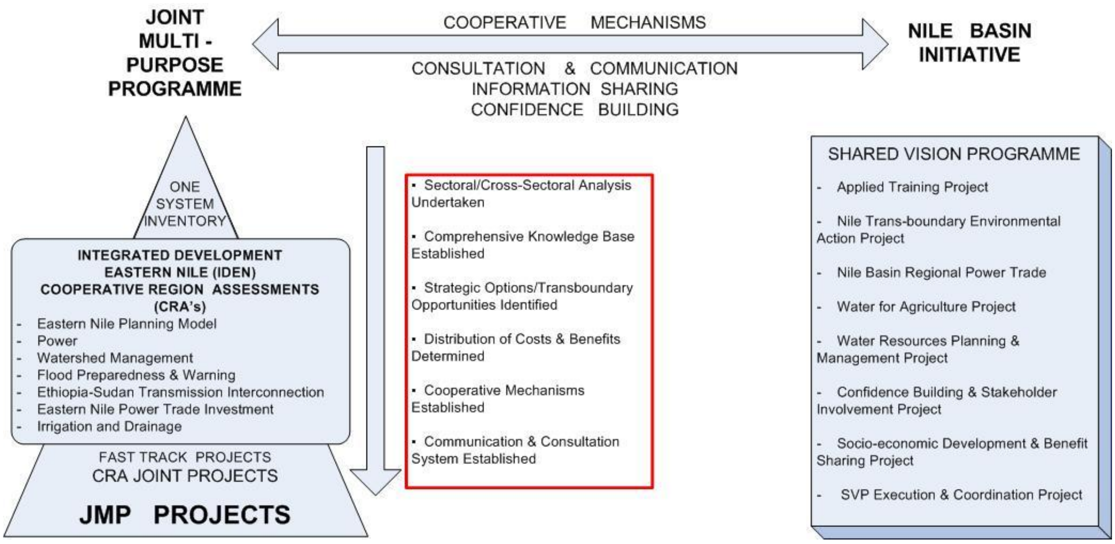


Figure 5.2 : Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme

It is expected that the results of the Watershed Management CRA will provide valuable input to the JMP planning. As may be seen in Figure 5.2, the Eastern Nile

Power Investment project (which may include Mandaya and/or Border HPP projects) and the Ethiopian-Sudan Transmission Interconnection are included as important components of the JMP.

Section 5.2 introduces the principal biophysical and socio-economic aspects of the Blue Nile sub-basin. Section 5.3 introduces the same aspects in relation to the Main Nile sub-basin. Some 24 figures are used to convey much of this information.

After describing the existing environments of the Blue and Main Nile, this chapter then draws attention to three areas (irrigation, hydropower and flooding), recognising that the primary impacts of river regulation caused by the Mandaya hydropower project (described in Chapters 6 and 7) will be hydrological and hydraulic, and that these will occur in the Abbay river downstream of Mandaya dam tailrace in Ethiopia, along the Blue Nile reach to Khartoum, and along the Main Nile in Sudan as far as Lake Nasser/Nubia and the High Aswan Dam.

Section 5.4 therefore introduces the key features of irrigation along the Blue and Main Nile.

Section 5.5 introduces hydropower reservoir developments along the Blue and Main Nile.

Section 5.6 introduces Sudan's flood warning system, and interprets this in relation to annual flood magnitudes and frequency which are beneficial or fail to be beneficial for flood recession agriculture, or too severe causing damage. Section 5.6 then introduces an assessment made from satellite imagery of areas of riverine agriculture/vegetation which are dependent on the Nile's annual flood. This anticipates the possible need to supply these by diversions and/or pumping if the project's reservoir and operations reduce annual floods significantly. Section 5.6 provides background for examining RAPSO simulation model output of floods in Chapter 7.

It may be noted that some of the discussion on the flood warning system relates to some aspects of "Flood Preparedness and Early Warning" which is another ingredient of JMP.

The chapter concludes with a summary of major problems identified in the CRA Report for Sudan (2006).

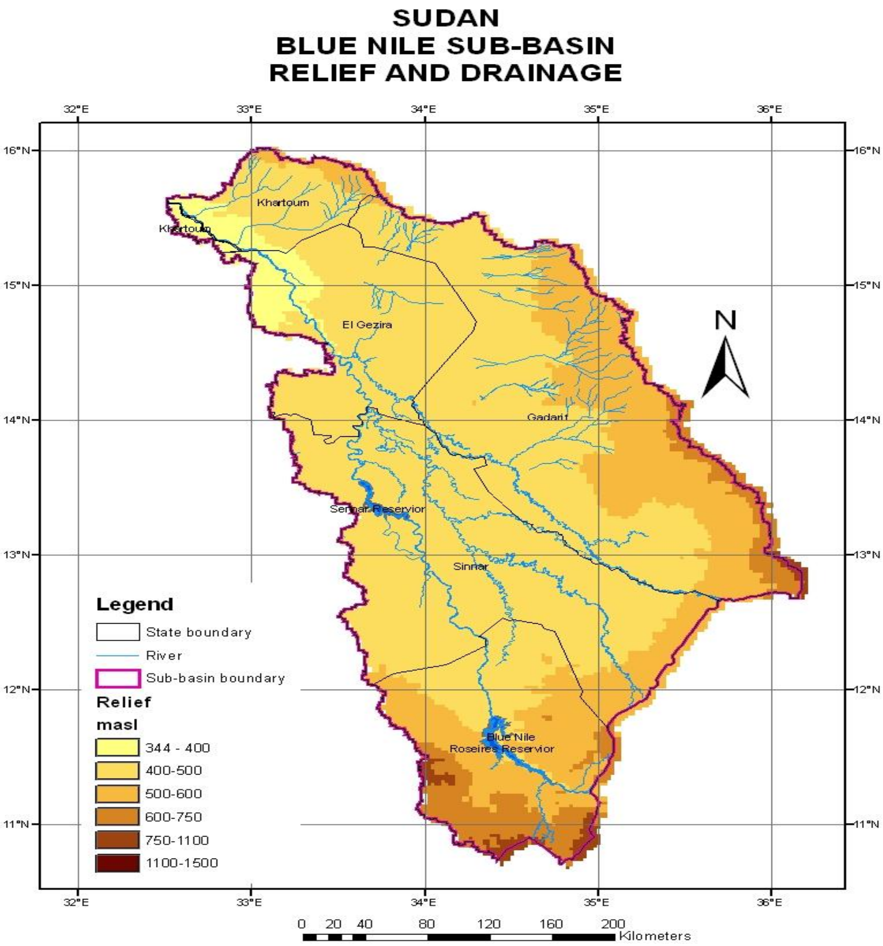
Where direct observations are available as a result of our visits to the Blue Nile in Khartoum and from field visits to Dongola and downstream as far as Dal (made for the Dal hydropower pre-feasibility and IEA report), these are included.

It is noted that all Nile flows reaching High Aswan Dam are comprehensively controlled by the large storage capacity in Lake Nasser/Nubia and operation of the High Aswan hydropower station and regulation release facilities for the Nile in Egypt. The Nile downstream of High Aswan Dam will remain completely controlled with or without the Mandaya and Border projects. For this reason, existing river conditions and principal river-based developments along the Nile in Egypt are not described. Descriptions of these are available in the CRA Country Report for Egypt (Hydrosult *et al,* 2007).

5.2 BLUE NILE ENVIRONMENT

5.2.1 Topography and Drainage

As the Blue Nile enters Sudan from Ethiopia it is confined in an incised channel. Before reaching the Roseires dam it flows through a wide area of colluvial and alluvial deposits. The basin comprises a very shallow valley between two interfluves of very low relief, the northern interfluve being of higher relief than that to the south. In addition to the Blue Nile, the Dinder and the Rahad rivers flow out of Ethiopia and join the Blue Nile below Sennar. A number of intermittent khores flow off the northern interfluve (Figure 5.3).

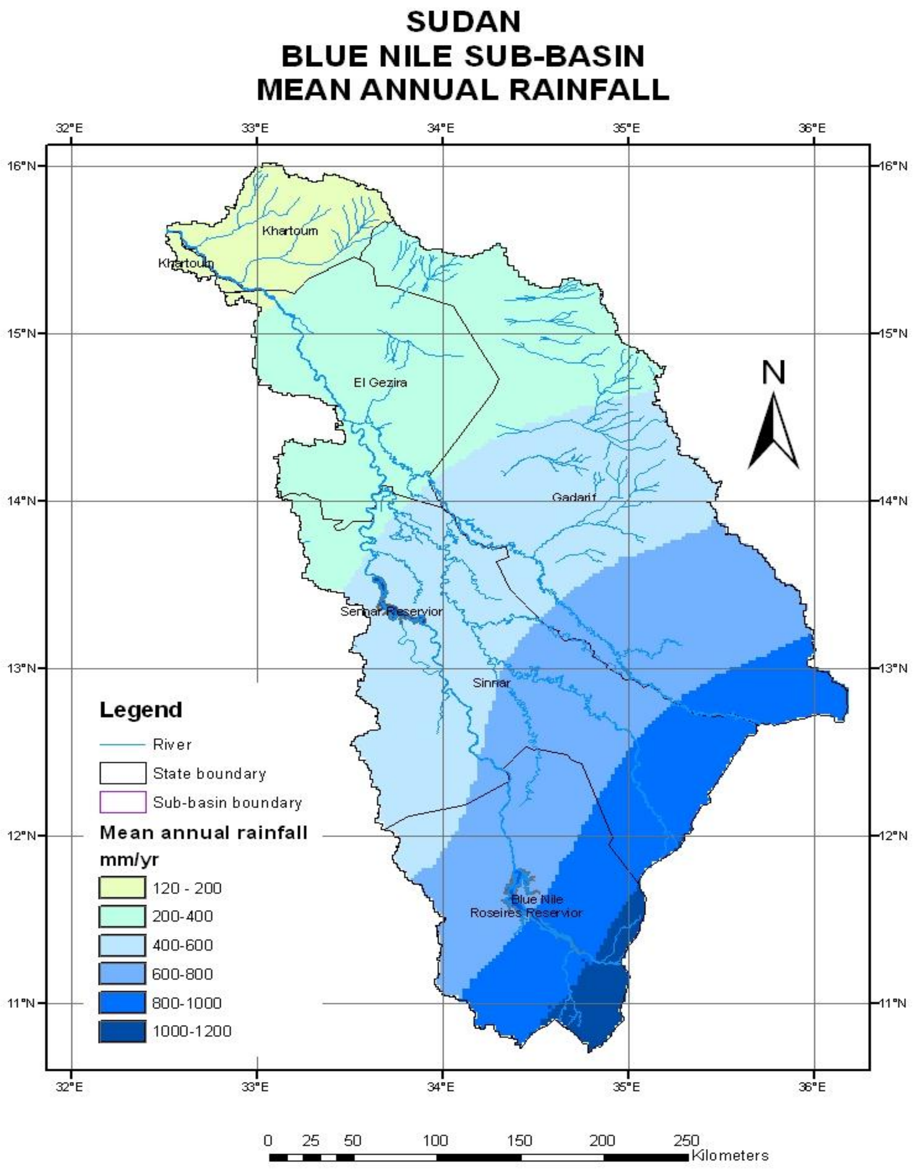


Source: CRA Sudan Report

Figure 5.3 : Blue Nile Sub-basin: Relief and Drainage

5.2.2 Rainfall

Mean annual rainfall in the Blue Nile sub-basin ranges from approximately 1,000 mm at the border with Ethiopia to 120 mm at Khartoum (Figure 5.4).

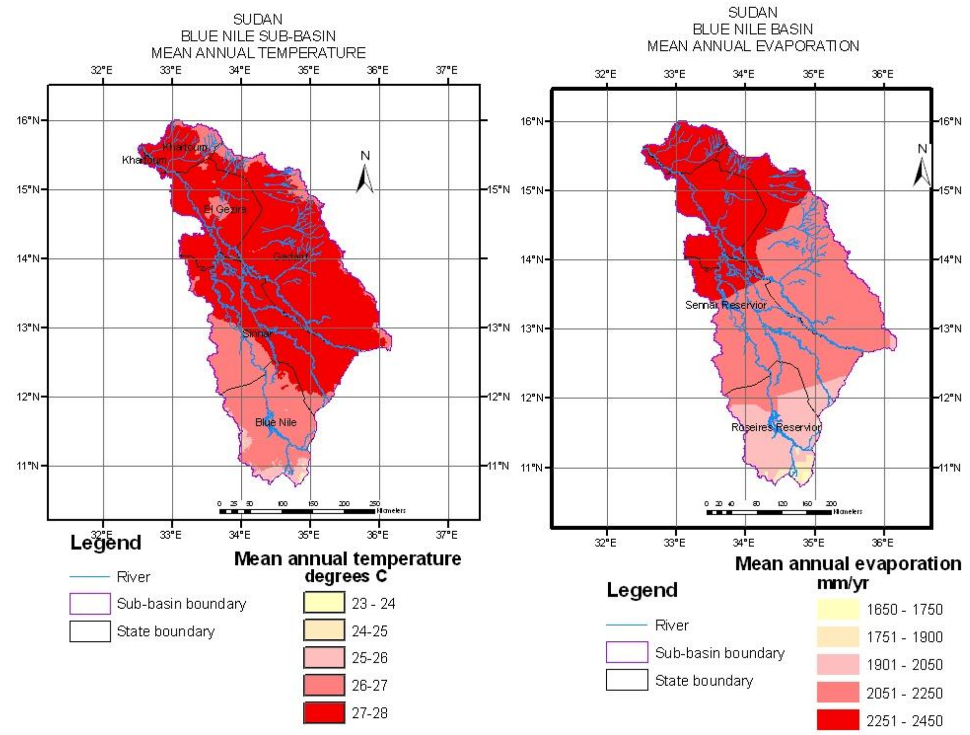


Source: CRA Sudan Report (2006)

Figure 5.4 : Blue Nile Sub-basin: Mean Annual Rainfall

5.2.3 Temperatures and Evaporation

Daily minimum and maximum temperatures in January are 14°C and 33°C and those in May are 24° and 44°C respectively. The mean annual temperature increases from 25°C at the border with Ethiopia to 28°C over the northern two-thirds of the sub-basin. Mean annual evaporation increases from 1,650 mm at the border with Ethiopia to 2,450 mm at Khartoum (Figure 5.5).



Source: CRA Sudan Report (2006)

Figure 5.5 : Blue Nile Sub-basin: Mean Annual temperature and Evaporation

It is important to note here that evaporation rates are a very consequential issue in the Nile basin. In accordance with the 1959 Nile Treaty, quantities of water lost to evaporation from reservoirs are deducted from Sudan's share of the Nile waters. Hence evaporation has to be particularly carefully considered in water-use planning.

Table 5.2 sets out the anticipated annual water losses to evaporation from the Blue Nile reservoirs (without and with Roseires heightening) and from existing and planned reservoirs on the Atbara river and Main Nile (Merowe reservoir) used in the RAPSO river simulation modelling in the engineering pre-feasibility study.

Table 5.2 : Annual evaporation from reservoirs

Nile Tributary	Project	Water Lost by Evaporation Mm3/year		
		2002	2012	2027
The Blue Nile	Roseires Reservoir	410	750 post heightening	750
	Sennar Reservoir	300	300	300
Atbara River	Girba Reservoir	170	170	170
	Upper Atbara Reservoir		400	400
Main Nile	Merowe Reservoir		1550	1550
Total		880	3,170	3,170

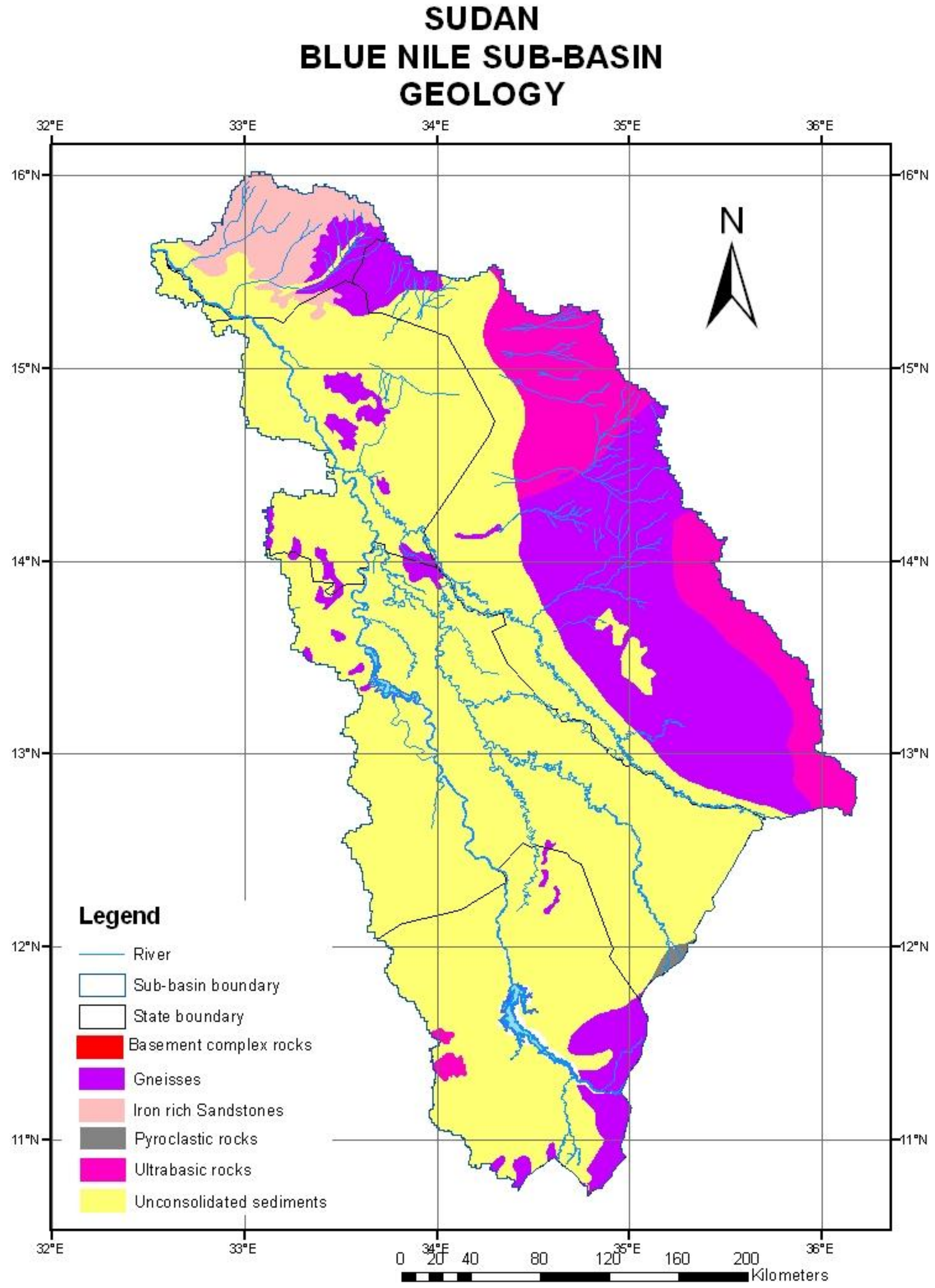
Source: RAPSO model, this study, and Sudan Meteorological Department

As described in the engineering pre-feasibility study, profiles of estimated monthly evaporation at each reservoir have been taken from previous studies where detailed information is available. Where only annual net evaporation information is reported the amounts in each month have been estimated from published Climatic Normals (1940/70). Representative net evaporation profiles were estimated from climatic data collected by the Sudan Meteorological Department at Karima (northern Sudan) and Wadi Medani (central Sudan) and these estimates have been applied to annual evaporation estimates at each project according to geographical location.

5.2.4 Geology

The geology along the Blue Nile river comprises the Gezira Quaternary and Recent alluvial sediments carried mainly from Ethiopia (figure 5.6). These rest unconformably on Nubian Sandstones. There are three main members: Upper Clay, Lower Sandy and the Mungata sandy Clay.

The Nubian Sandstones outcrop in the north near Khartoum where they consist of conglomerates, sandstones and mudstones. The watershed between the Blue Nile and the Atbara to the north is underlain by Basement Complex gneisses, schists and granites.



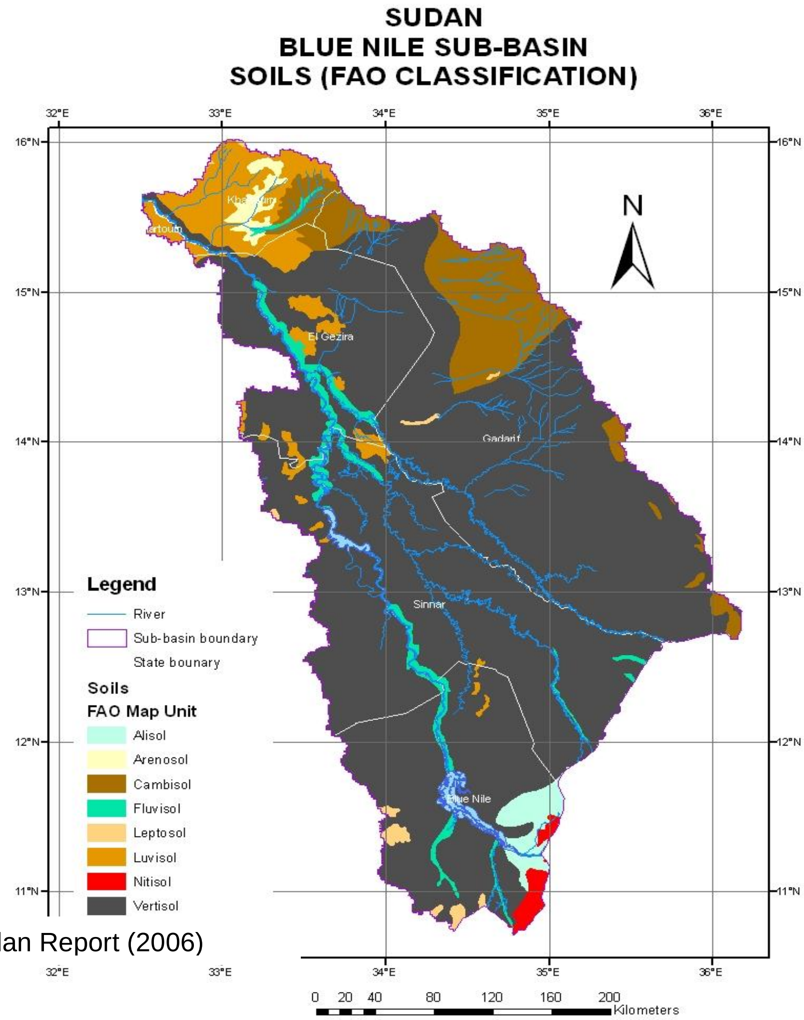
Source: CRA Sudan Report (2006)

Figure 5.6 : Blue Nile Sub-basin: Geology

5.2.5 Soils

Vertisols occupy most of the Blue Nile Sub-basin (Figure 5.7). They are very deep with a relatively low water table, comprising clay to sandy clay textures for 3 to 4 m or more and underlain by sand or gravel. They are alkaline, very poorly drained and difficult to work when wet. Whilst some of these soils have been irrigated for 70 years or more, there is no evidence of salts rising or accumulating (Gun, 1983). Although apparently uniform, they exhibit subtle differences in colour and self-mulching properties of the surface horizons. Surface colours are dark grey-brown except in the long shallow, closed depressions where dark-grey colours are associated with seasonal waterlogging.

So far as the Mandaya and Border projects are concerned, it is noted that construction of pylon towers for their interconnecting transmission lines to Hasaheisa or Rabak, and road access for construction and maintenance of these, will involve traversing these vertisols along most of the route.



Source: CRA Sudan Report (2006)

Figure 5.7 : Blue Nile Sub-basin: Dominant Soil Types (FAO Classification)

5.2.6 Land Cover and Vegetation

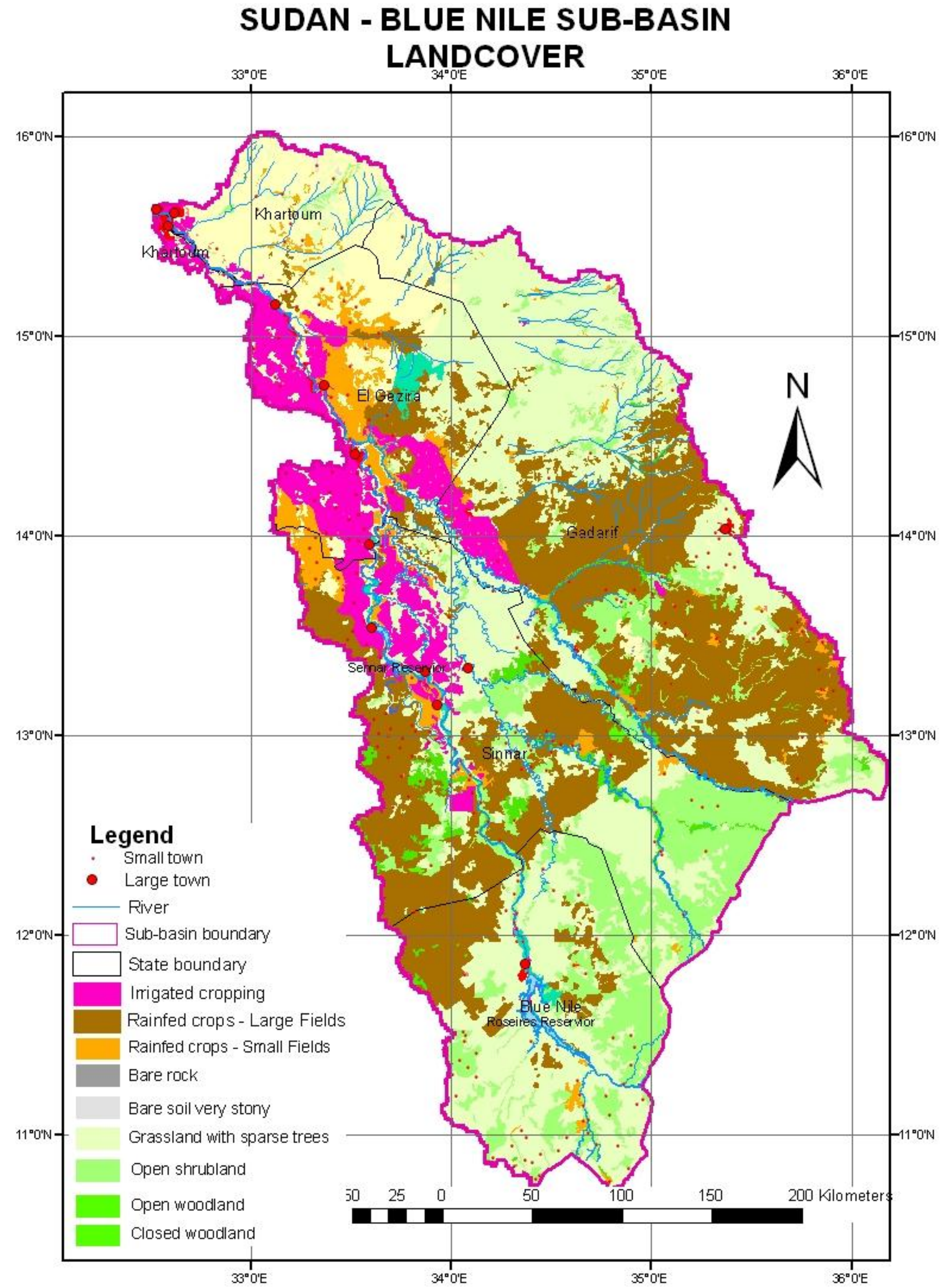
The Blue Nile sub-basin has experienced more removal of its original vegetation compared with others, first from large-scale development of irrigation, and latterly from the large expansion of semi-mechanized farms.

The patterns of natural vegetation closely follow those of mean annual rainfall, although locally edaphic conditions can provide a stronger influence (Figure 5.8). However, the biotic factors (grazing, cutting, burning and cultivation) are now of almost equal importance to the physical environment in determining the exact composition of vegetation communities.

In the southern portion of the sub-basin, from where mean annual rainfall is above approximately 570 mm to 1,000 mm at the Ethiopian border, savanna predominates comprising species *Acacia seyal* in association with *Balanites aegyptiaca*. *A. senegal* is retained for gum arabic harvesting whilst *A. seyal* is used for charcoal production. *B. aegyptiaca* becomes increasing prevalent because it is fire resistant, does not produce good charcoal and is hard to cut. The grasses tend to occur in pure stands of *Hyparrhenia anthistirriodes* or *Cymbopogon nervatus* with *Sorghum spp*. in the higher rainfall areas. These grasses become largely unpalatable to livestock during the dry season. There is abundant material for annual fires.

Further north, Acacia thorn land alternates with grassland. Between the 360 and 570 mm isohyets on the heavy clays, grassland merges into *A. mellifera* thorn land. Other tree species include *A. nubica, C. decidua, Cadaba glandulosa, C. rotundifolia and Boscia senegalensis.* The last three species often persist after *A. mellifera* has been cleared. Much of this vegetation is being cleared for small-scale sedentary and large-scale semi-mechanised agriculture. Grass species include *Cymbopogan nervantus*, *Sorghum purpereo-sericeum*, *Hypparhenia ruffa*, *Tetropogan cenchriformis* and *Cenchrus cilliaris*. Sufficient grass dry matter is produced to provide material for annual burning.

As along the Abbay in Benishangul Gumuz region, pure stands of riverine woodland – “*sunt*” – are increasingly under pressure. The first trees to colonize a newly formed river bank are *Salix subserrata* and *Tamarix nilotica*. As the bank builds up, xerophytic species such as *Ziziphus spina-christi* become established. On the lower terrace *A. nilotica* establishes itself, with *A. seyal* on the higher ground.



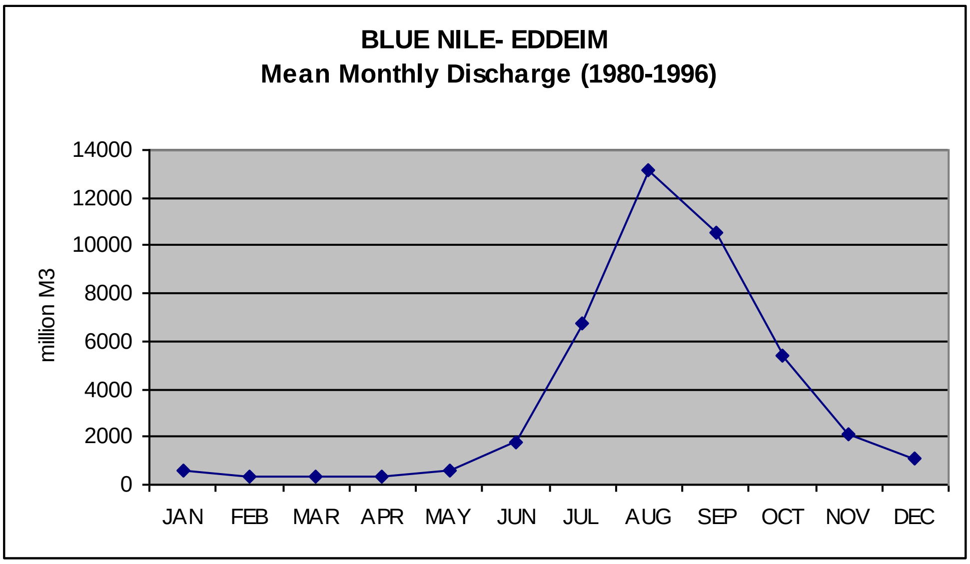
Source: CRA Sudan Report (2006)

Figure 5.8 : Blue Nile Sub-basin: Land Cover

5.2.7 Surface Water Resources and Sediment Transport

The Blue Nile and its two tributaries the Dinder and Rahad rise in the Ethiopian Highlands. The Blue Nile drops 120m between the Ethiopian border and Khartoum. The annual average flow near the Ethiopian border at El Deim has been assessed at approximately 49 billion m^3, with an addition 4 billion m^3 coming from the Rahad and Dinder. There is little or no flow from these tributaries during the dry season.

As described in Chapter 4, there is great variability in seasonal and yearly Abbay/Blue Nile flows. Peak discharges are normally in August and lowest discharge in the early months of each year (Figure 5.9).

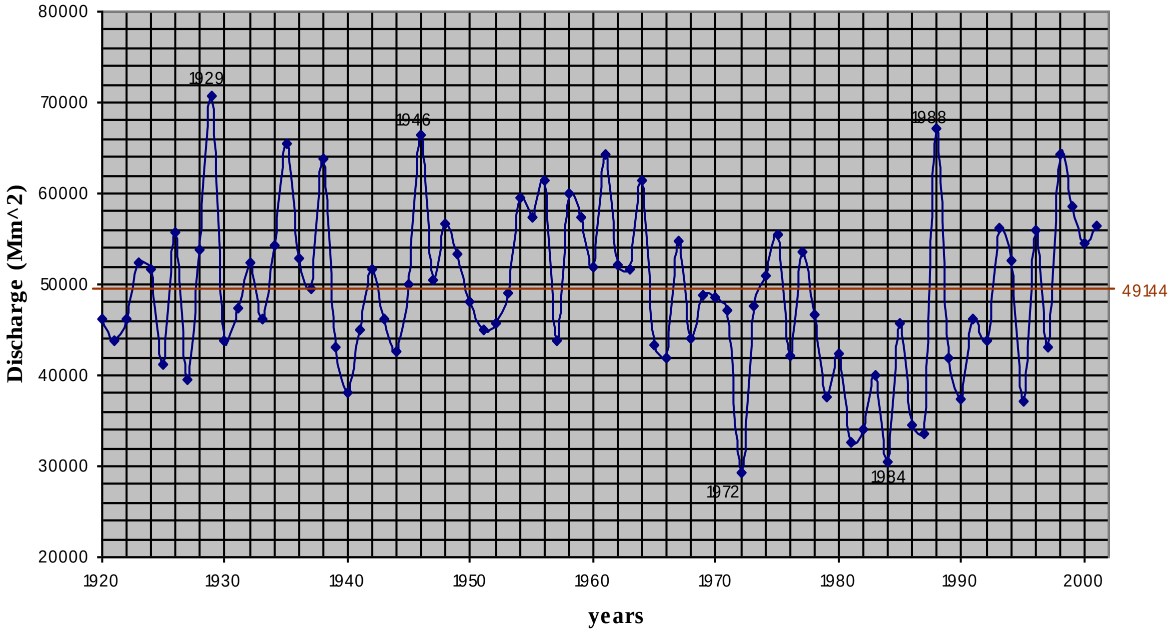


Source: CRA Sudan Report (2006)

Figure 5.9 : Mean monthly discharge of Blue Nile at El Deim – 1980-1996

By contrast, the White Nile flow at its confluence with Blue Nile in Khartoum is much more uniform. This is attributed to natural regulation effects of Lake Victoria and other lakes and swamps.

Annual discharges of the Blue Nile for the 82-year period 1920 to 2001 are shown in Figure 5.10. Between 1920 and 1960 the annual discharge oscillated around the mean flow without long continuous sequences of above or below average conditions. From 1960 to 1984 there was a general decrease in discharge. The long series of drought years ended in the major flood year of 1988, since when annual flows have fluctuated around the mean without long continuous sequences of above or below average conditions. What is not shown is the very severe drought year of 1913 when the Blue Nile flow was similar to or lower than in 1972 and 1984 (see Figure 5.19).



Source: CRA Sudan Report (2006). Units are million m^3

Figure 5.10 : Blue Nile Hydrograph 1920 - 2001

Sediment transport in the upper Blue Nile in Sudan was discussed in Section 4.1.5/6 in relation to El Deim and Roseires, with recent estimates ranging between 140 and 318 Mt/year (Table 4.9). The Ministry of Irrigation and Water Resources has provided some maximum suspended sediment concentration data of Blue Nile at Khartoum for recent years: 17,400 ppm on 15/08/02; 18,350 ppm on 02/08/03; 25,000 ppm on 04/08/06. Maxima for earlier years were not provided for comparison but these values, if natural and not exaggerated by flushing at Roseires and Sennar upstream, appear to support the proposition that sediment transport is greater than ever experienced before.

5.2.8 Groundwater

The hydro-geological system comprises upper and lower aquifers. The upper aquifer includes mainly the Upper Gezira Formation, the upper part of the Lower Gezira formation in the area between the Blue and White Nile, and the upper part of the Lower Omdurman Formation to the north of the Blue Nile. The lower aquifer is developed mainly in the deeper Nubian Sandstones. Water storage in the lower aquifer is some eight times that of the upper aquifer. Except for a few isolated localities water quality is free from impurities for drinking and irrigation requirements.

5.2.9 Fisheries, Mercury and Wetlands

According to FAO (2001), Roseires reservoir has a potential of 1,700 tons/year and fish landings of 1,500 tons/year (88%) from a surface area of 290 km^2. 22 fish species, 1,200 fishermen and 550 boats are reported to be involved.

Sennar Reservoir has an estimated fish capacity of 1,100 tons/year and a fish yield of 1,000 tons/year (91%) from a surface area of 140 – 160 km^2. 22 fish species (the same number as at Roseires), 800 fishermen and 450 boats are reported to be involved.

By comparison, Lake Nubia's potential is 5,100 tons/year but is able to produce only 1,000 tons of fish annually (20%).

Applied research and transfer of technology is the mandatory responsibility of the Fisheries Research Centre, Animal Resources Research Corporation of the Ministry of Science and Technology. The Fisheries Research Centre has a research station at Roseires (El Damazin).

According to an investigation relating to gold mining and use of mercury, fish caught in Roseires reservoir supply fish markets of the Blue Nile, Gezira and Khartoum states. Nile perch (*Lates niloticus*) and Tilapia (*Tilapia nilotica*) are the major species consumed. Concerns are being expressed by GEF, UNDP and UNIDO about potential health risks associated with mercury entering Roseires reservoir from tributaries draining from gold processing areas in the Ingessana hills to the south of the reservoir (Ibrahim, 2003).

After Roseires dam was constructed, the reservoir water stratified soon after filling, with complete de-oxygenation of the lower layers and, in 1967 there was a heavy fish mortality when de-oxygenation affected all the water temporarily. Migrating fish have been reported to congregate in large numbers below Roseires dam every year during March and April and suffer high mortality due to low dissolved oxygen and starvation (El Moghraby, 1979).

It is noted that fish ladders were installed at Sennar and Jebel Aulia dams. At Sennar it was destroyed and not replaced. At Jebel Aulia dam on White Nile, the ladder had poor entrance conditions (a common problem) and many migrating Nile perch were unable to surmount it.

The main wetlands in the Blue Nile sub-basin are located on and between the Dinder and Rahad right bank tributaries of the Blue Nile and are locally known as "*maya'as*". These are depressions along and between these tributary rivers. The areas further away from the river are covered with fossil streams and rivers. The depressions are abandoned meanders which have formed "ox-bow" lakes. These lakes however are ephemeral as they gradually silt up, fill with swamp vegetation and then, as they silt up, dry out. The maya’as do not appear to be recharged or sustained by Blue Nile flood discharges. They are important wetlands. The Mandaya to Hasaheisa (or Rabak) transmission line will avoid these because its alignment is on the west bank of the Blue Nile.

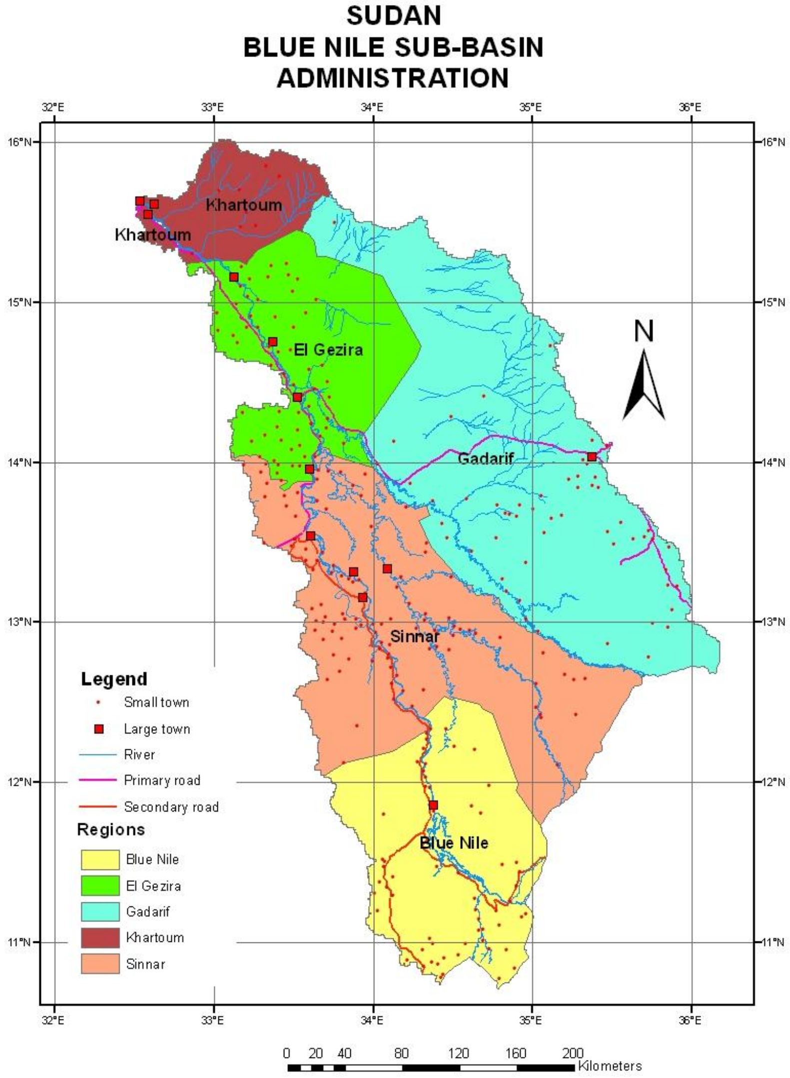
5.2.10 Socio-economic characteristics of Blue Nile sub-basin

The Blue Nile sub-basin has five Administrative Regions as shown in Table 5.3 and Figure 5.11.

Table 5.3 : Administrative Regions

Region	Area (km^2)	% of Sub-basin
Blue Nile	20,208	**17**
El Gezira	16,420	**14**
Khartoum	7,111	**6**
Al Gadarif	41,136	**35**
Sennar	31,698	**27**
SUB-BASIN	116,573	

Source: CRA Sudan Report (2006)



Source: CRA Sudan Report (2006)

Figure 5.11 : Blue Nile Sub-basin: Administrative Regions

5.2.11 Population

The population of the States contained mainly within the Blue Nile Sub-Basin is as follows:

Al Gadarif	1,151,050
Khartoum State	2,105,800
Gezira	1,919,580
Sennar	1,091,640
Blue Nile	338,290
Total	6,606,360

The main population is concentrated along the west side of the Blue Nile from Khartoum to El Damson. This is related to the Gezira irrigation scheme and the towns along the main road that service the scheme. Smaller concentrations are seen along the Sennar to El Kaferif road, and up the Dinder Valley. The latter are related to the Rahad Irrigation Scheme.

5.2.12 Demographic Characteristics and Population Density

The demographic characteristics of States within the Blue Nile sub-basin are similar and much closer to the average of the Northern States, as shown in Table 5.4. Khartoum is noticeable because of its lower birth, death and infant mortality rates.

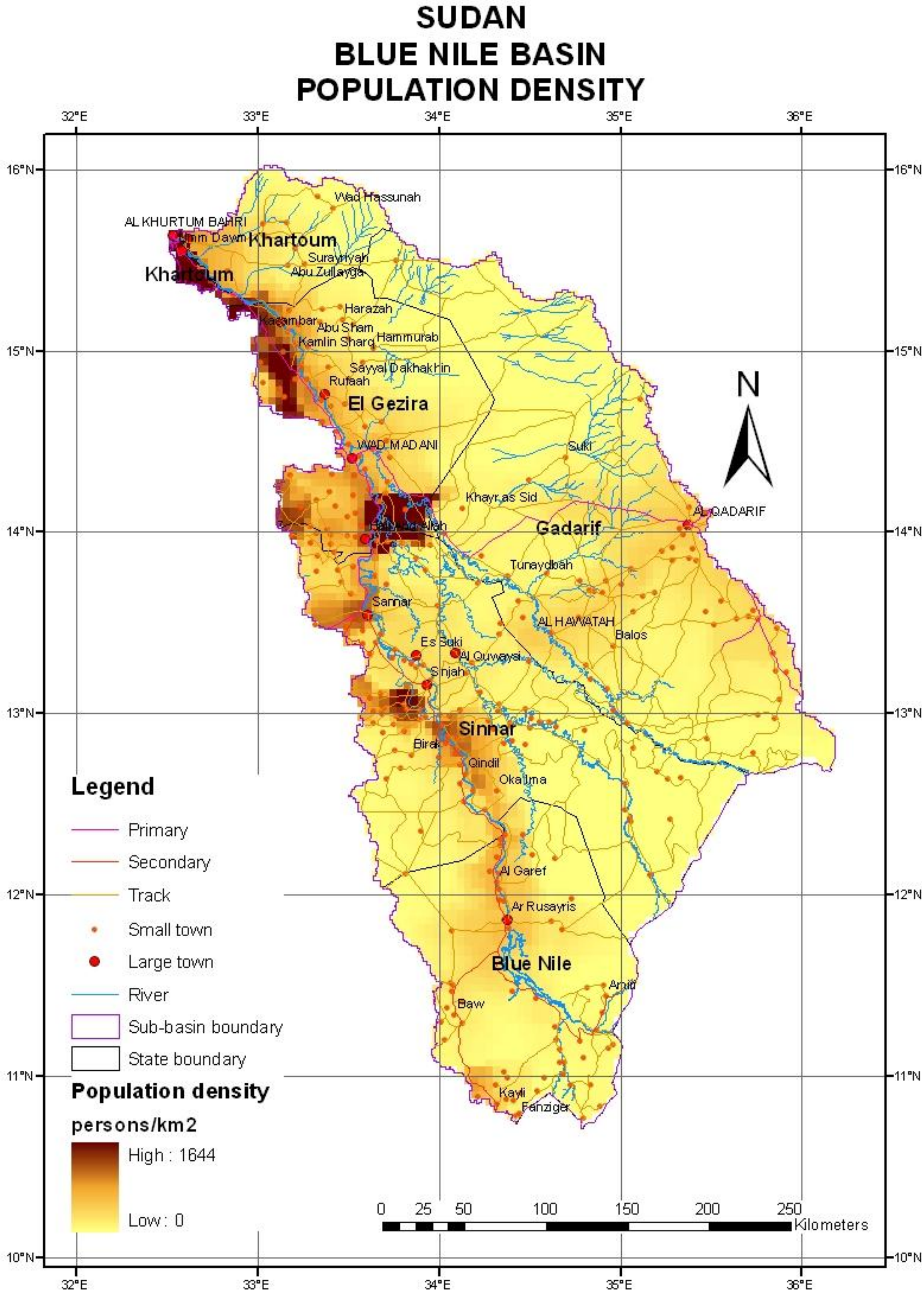
Table 5.4 : Administrative States - Demographic Characteristics

State	Growth rate %	Urban %	% <15yrs	% >60yrs	Sex ratio M/F	Crude birth rate	Crude death rate	Infant mort. male*	Infant mort. female*
Blue Nile	3.00	25.2	42.7	3.7	108.3	38.5	12.3	137	122
Al Gadarif	3.40	28.9	43.1	3.7	105.3	40.3	11.7	135	122
Khartoum	4.00	86.7	36.5	3.8	111.3	33.7	8.8	98	85
El Gezira	3.00	22.4	42.5	4.4	96.8	38.5	9.5	101	76
Sennar	2.60	28.3	44.5	4.0	98.8	39.9	10.9	121	109
NORTH SUDAN	2.80	37.3	42.8	4.1	100.4	37.8	11.0	116	98

* per 1,000 live births

Source: CRA Sudan Report (2006)

The population density of the sub-basin is shown in Figure 5.12.



Source: CRA Sudan Report (2006)

Figure 5.12 : Blue Nile Sub-basin: Population Density

5.2.13 Literacy and Education

Literacy and primary school enrolment rates for the Blue Nile sub-basin States and North Sudan are shown in Table 5.5

Table 5.5 : Blue Nile Sub-basin: Literacy and Primary School Enrolment Rates

State	Literacy >15yrs % Average	Literacy >15yrs % Male	Literacy > 15yrs % Female	Population 6-13yrs	Total Primary school enrolment	Enrolment %
Blue Nile	31.3	41.8	20.4	143,305	48,914	34.1
Al Gadarif	55.6	72.9	38.4	311,547	142,313	45.7
Khartoum	73.6	81.1	65.0	795,983	659,028	82.8
El Gezira	65.2	75.5	55.8	658,547	538,183	81.7
Sennar	52	64.5	40.0	267,649	146,090	54.6
NORTH SUDAN	**54.5**	**66.6**	**42.4**	**6,493,230**	**3,308,387**	**51.0**

Source: CRA Sudan Report (2006)

There are significant differences in literacy and primary school enrolment rates between Khartoum and El Gezira States and Blue Nile and Sennar States. The former is considerably above the Sudan national average. Gezira's literacy rate is significantly below the average for Northern Sudan. In all states female literacy rates are below those for males, although for Khartoum and El Gezira they are above the average for Northern Sudan.

5.2.14 Water supply and Sanitation

The proportions of population (%) with access to drinking water and sanitation facilities are shown in Tables 5.6 and 5.7. In terms of water supply Khartoum and El Gezira States are well above the Northern States' average for piped water, whilst Blue Nile State is particularly deficient. With respect to sanitation facilities, Khartoum is well above the average and Al Gadarif State well below.

Table 5.6 : Blue Nile Sub-basin: Access to Drinking Water by Source

State	Main source of water							
	Piped into dwelling	Public tap	Deep Well/pump	Dug Well/ bucket	River/canal	Rainwater	Others	Missing
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13	0
Al Gadarif	12.6	18.8	27.7	13.9	13.8	9.4	3.6	0.2
Khartoum	59.8	3.5	29.5	2.4	0.2	1.6	2.9	--
El Gezira	47.2	14.1	16.6	6.6	12	0.2	3.3	--
Sinnar	30.2	11.3	32.4	0.6	8.1	9.3	7.6	0.4
NORTH SUDAN	**50.8**	**4.3**	**15.8**	**9.8**	**12.8**	**--**	**6.4**	**0.1**

Source: CRA Sudan Report (2006)

Table 5.7 : Blue Nile Sub-basin: Sanitation Facilities by type

State	Flush to Sewage System	Flush to septic tank	Traditional pit latrine	Soak away pit	Others	Missing	No facilities
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
Al Gadarif	--	5.0	31.7	3.1	0	0	60.1
Khartoum	1.1	11.2	73.8	0.9	3.1	0.4	9.5
El Gezira	--	4.2	51.7	2.1	1.7	0.2	40.0
Sinnar	--	2.7	46.6	5.3	2.1	0.7	42.7
NORTH SUDAN	**--**	**7.7**	**69.2**	**1.6**	**1.6**	**--**	**19.9**

Source: CRA Sudan Report (2006) after UN Population Fund & Sudan Central Bureau of Statistics. (2002)

5.2.15 Socio Cultural Aspects of the Population

A substantial proportion of the population in the Blue Nile Sub-basin live and work on the large irrigation schemes and semi-mechanized farms or in service and processing industries related to these developments. Many in the past followed pastoralist and agro-pastoralist livelihoods but who, for one reason or another, lost their livestock and became sedentarized.

There are a number of groups of people who retain their original way of life, although now somewhat altered. The Rufa'a al-Hoi are an Arab speaking Muslim nomadic people with sheep, cattle and camels and are divided into two groups: the northern Badiya located on the Blue Nile (dry season) and who move north towards the Dinder River (wet season); and the southern Badiya who used to move between the Yabus (in the dry season) and the Gezira/Managil schemes (in the wet season). As well as livestock production, gum collection (from *A. seyal*) and sorghum cropping supplement their livelihoods. In the past two decades, and particularly after the 1984 drought, there have been an increasing number of Rufa'a al-Hoi people without livestock becoming sedentarized. Following the abolition of the Native Authorities many sedentary villages ran their own village councils and the power of the Rufa'a al-Hoi declined. The recent installation of the Federal structure has further weakened the power of the Rufa'a al-Hoi and so increased that of the sedentary people.

The Kenana are also Arab speaking pastoralists who move between the Blue Nile northwards beyond the Dinder River. They come into contact with the northern Badiya group of Rufa'a el-Hoi along the Blue Nile.

The Fulani are a mixture of many ethnic groups from West Africa who moved into the Funj in the mid 1940's, were expelled to western Sudan in 1954 but have since returned. They have the West African long horned cattle that are fast walkers but poor milkers. The Fulani follow the same transhumant patterns as the Rufa'a al-Hoi but at slightly different times usually leaving the dry season grazing area later. They are said to remain out of contact with government tax and veterinary agents, often moving at night. The Baggara are an Arab speaking pastoral people from west of the White Nile who cross over in the dry season and also graze to the north of the

Machar Swamps. They only enter the southern Funj area in the dry season, their home area being west of the White Nile.

The Ingessana is a name given to the people living in the Ingessana Hills with a distinctive language and culture. They are predominantly agriculturalists cultivating the foothills. Cattle, goats and camels are socially and economically important. Livestock are kept in the hills during the wet season and move either south-eastwards to the Machar Marches and the Yabus, and to the east to the Blue Nile and the border with Ethiopia. They maintain a spirit of cooperation with the Rufa'a al-Hoi and many Ingessana work as herders for them. Some Ingessana are involved in gold mining in the Ingessana Hills, south of Roseires reservoir. As well as the Ingessana, there are a number of smaller groups who practise sedentary agriculture. These include the Berta, Gumuz and Burun, and along the Blue Nile many peoples from western and northern Sudan who arrived after the Mahdist rule.

5.2.16 Transport Infrastructure

Within the Blue Nile sub-basin there are two primary roads (asphalt) and one all-weather secondary road (Figure 5.13) as follows:

(a) Primary Roads

Khartoum- Wad Medani (187 km) – Al Gadarif (187 km)

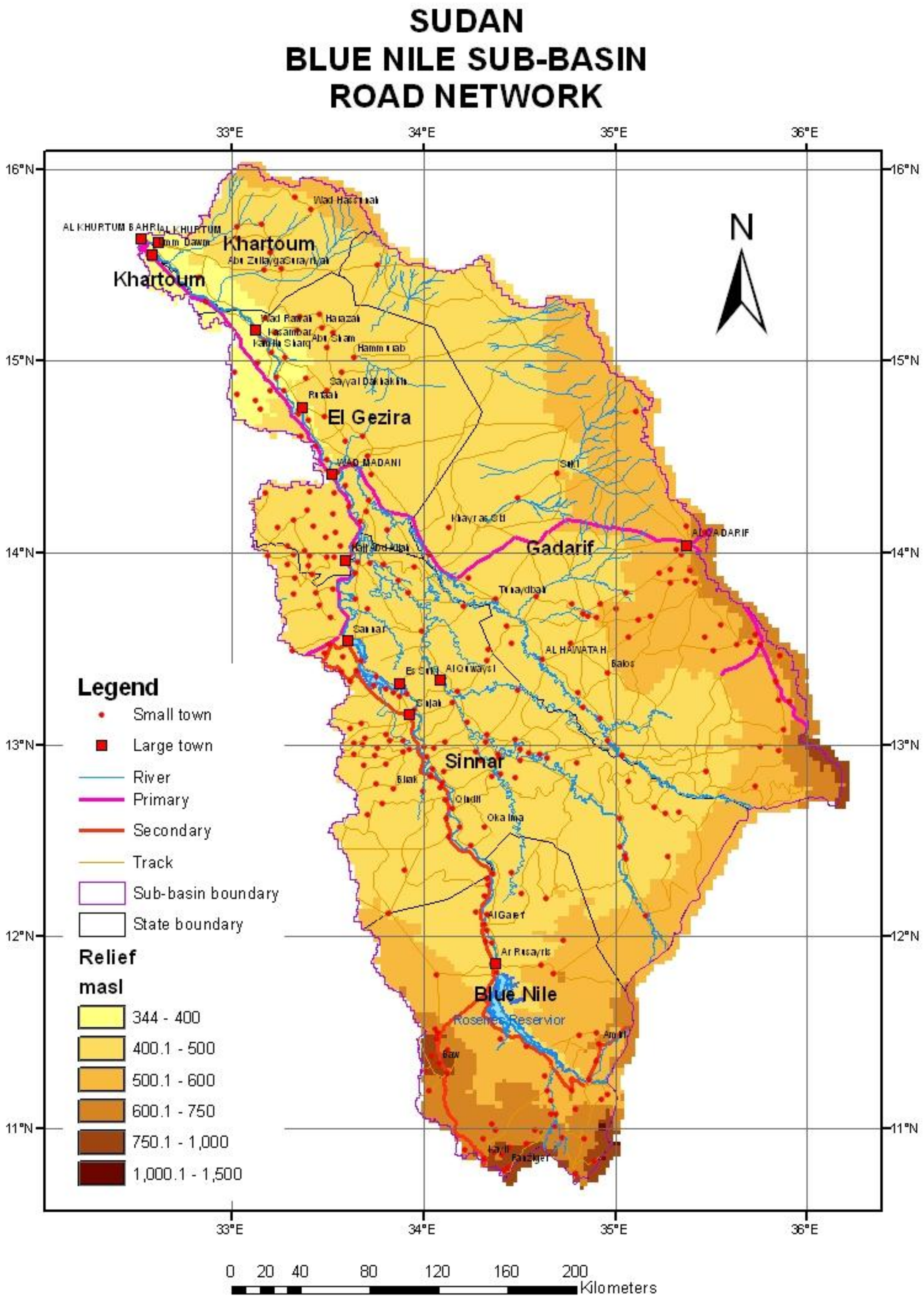
Wad Medani - Sennar (50km) – Damazin (278 km)

(b) Secondary Roads

Al Gadarif – Metema (159 km)

Other roads are generally in poor condition. On the clay plains they are often impassable during the rains.

There is one rail network: Khartoum – Sennar – Al Gadarif.



Source: CRA Sudan Report (2006)

Figure 5.13 : Sudan – Blue Nile Sub-basin: Road network

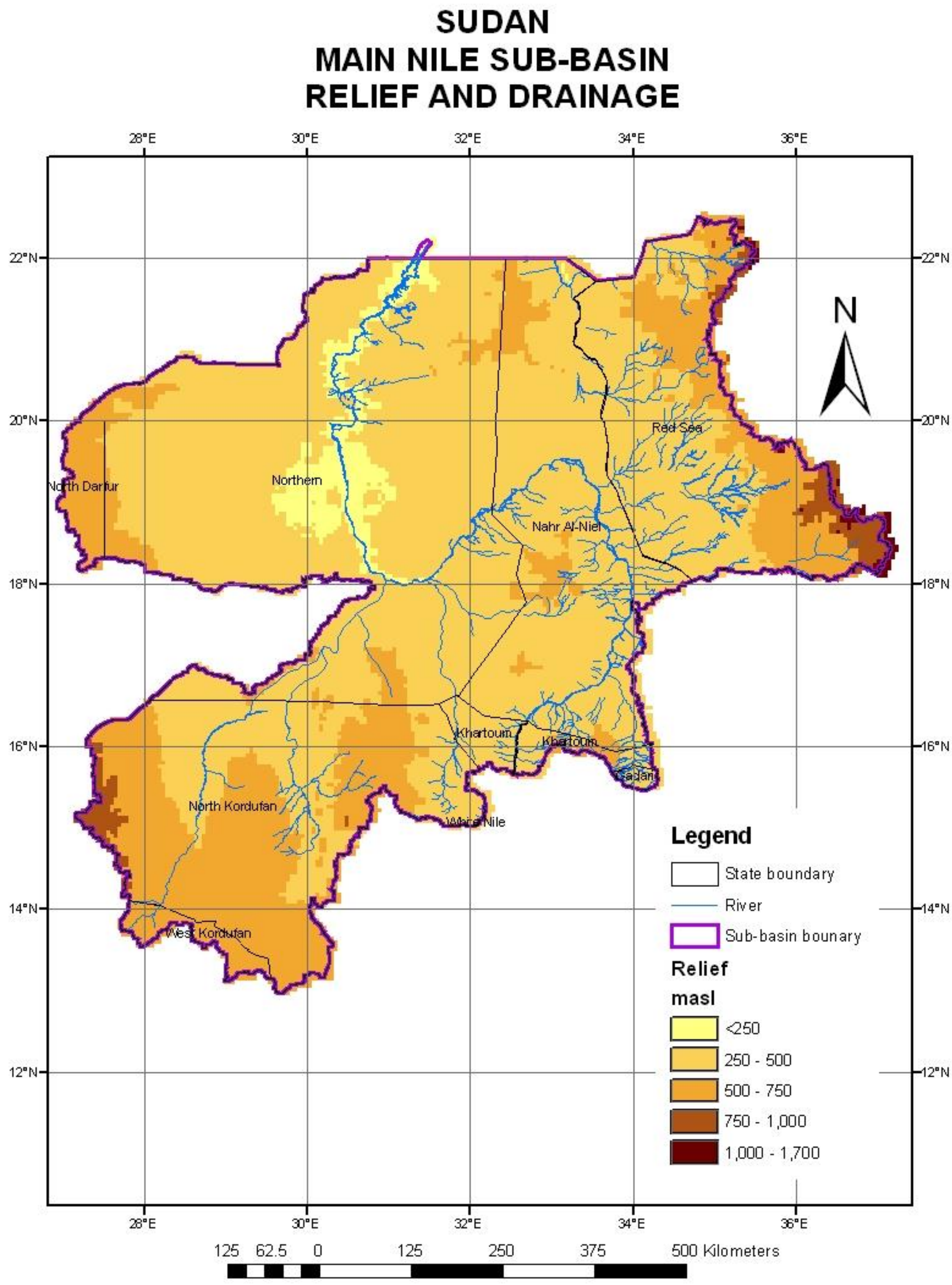
5.3 MAIN NILE ENVIRONMENT

5.3.1 Topography and Drainage

The Main Nile in Sudan lies within a broad gently sloping basin extending some 582,368 km^2 or 49% of the Eastern Nile Basin within the Sudan.

The main feature is the large S-shaped loop made by the Nile, beginning at the Blue and White Nile confluence in Khartoum and ending in Lake Nubia in the north, a distance of some 1,500 km (Figure 5.14). The river flows through a series of cataracts with a total drop of 250m. This long reach is the principal focus of attention for considering impacts of regulatory storage projects in Ethiopia.

Many ephemeral watercourses (wadis and khors) drain towards the Main Nile but deliver flows for short-lived periods and very rarely. The only major seasonal tributary is the Atbara joining the right bank of the Nile. Wadi El Milk is the largest wadi on the west bank.

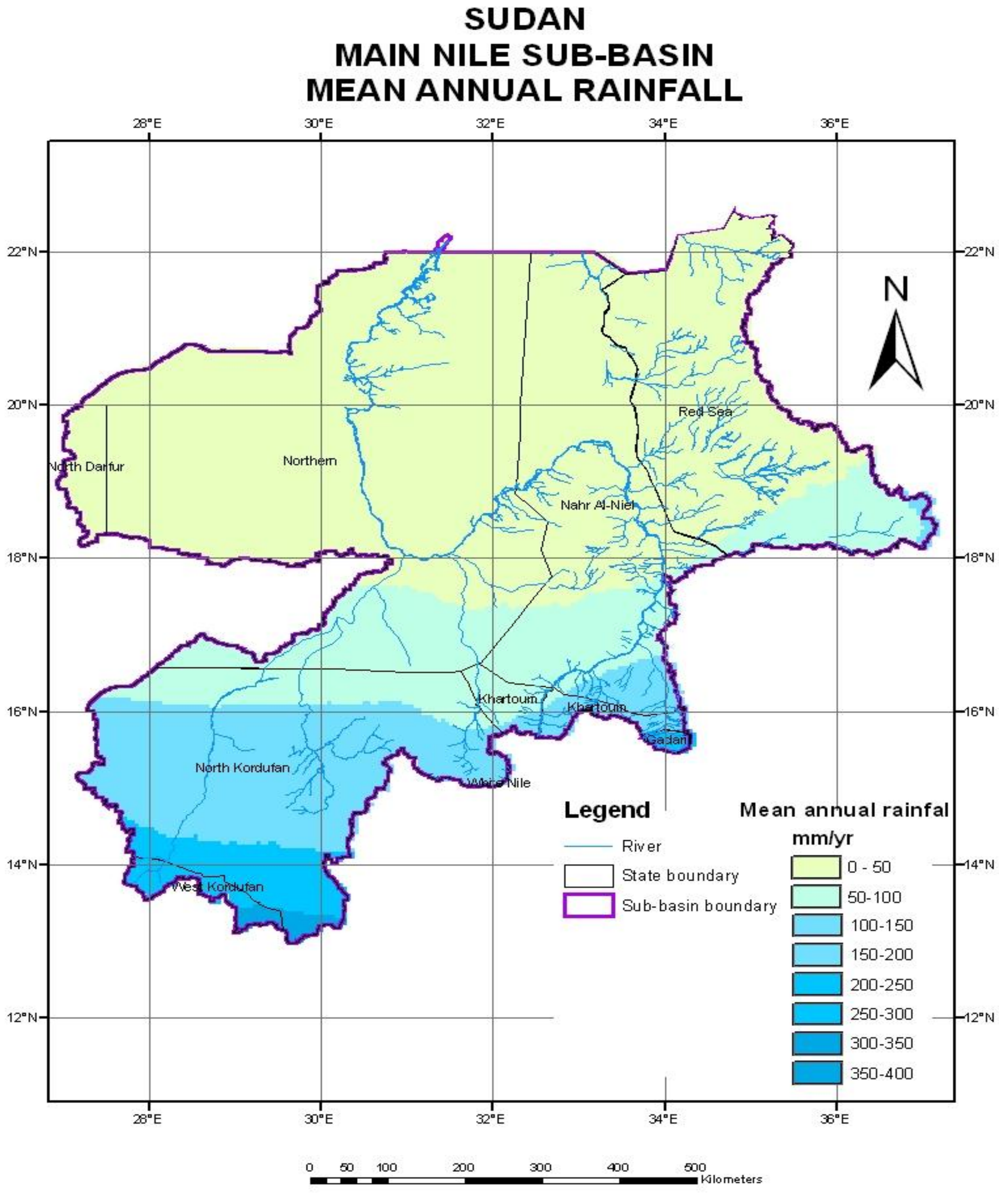


Source: CRA Sudan Report (2006)

Figure 5.14 : Main Nile: Relief and Drainage

5.3.2 Rainfall

Mean annual rainfall along the Main Nile river course is low and erratic, varying between 150 mm near Khartoum and less than 25 mm in the north. Rain falls mainly between July and September (Figure 5.15).



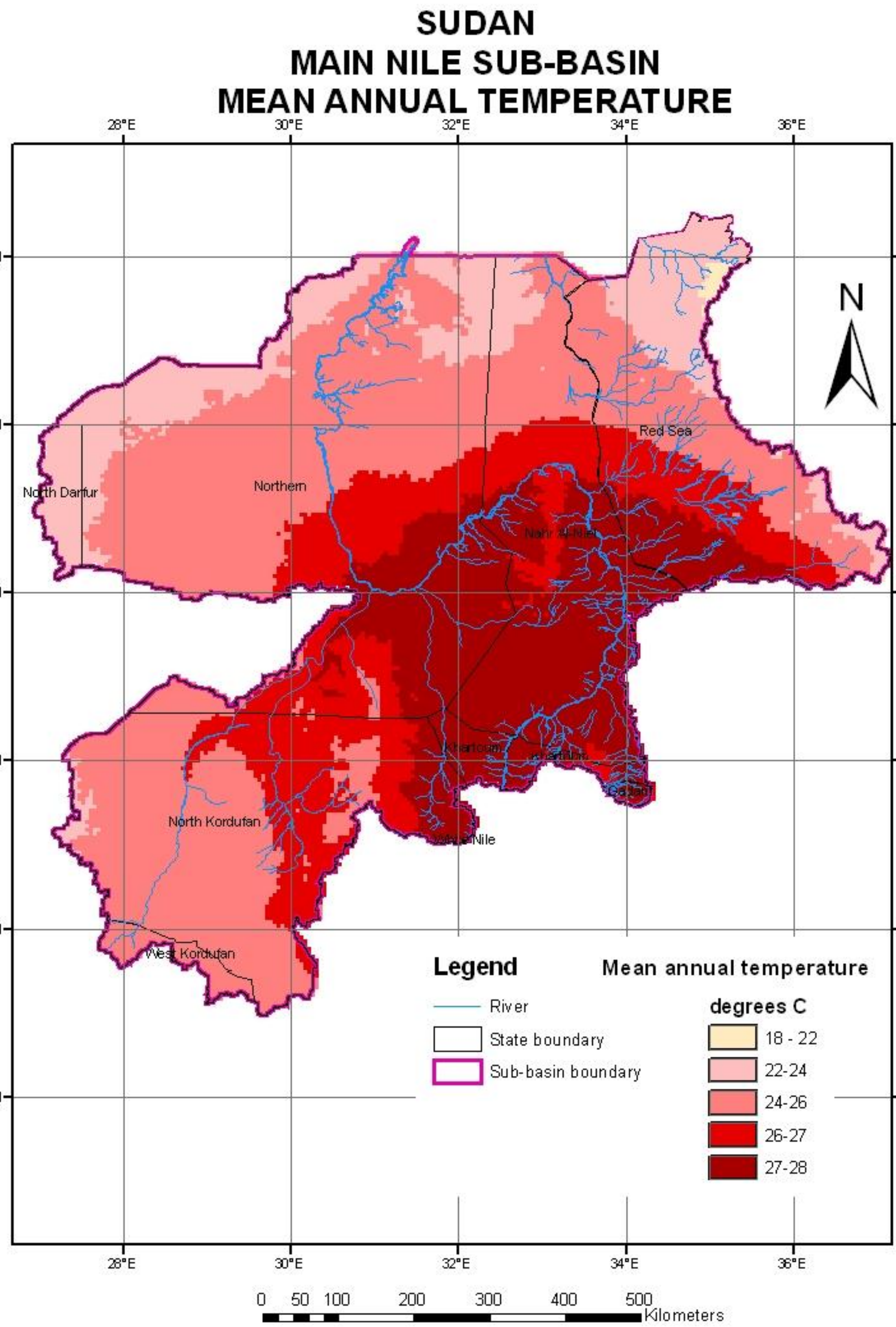
Source: CRA Sudan Report (2006)

Figure 5.15 : Main Nile: Mean annual rainfall

5.3.3 Temperatures and evaporation

Highest mean annual temperatures (27 – 28 °C) occur along the Main Nile river course from Khartoum to the centre of the long reach between Merowe and Dongola (Figure 5.16). Mean annual temperature around Lake Nubia is slightly lower owing to the more northerly latitude with a slightly stronger winter effect (24 – 26 °C).

Evaporation rates are correspondingly high. Daily rates range between 12 mm/day in August, the month with maximum cloud cover, and 21 mm/day in May.



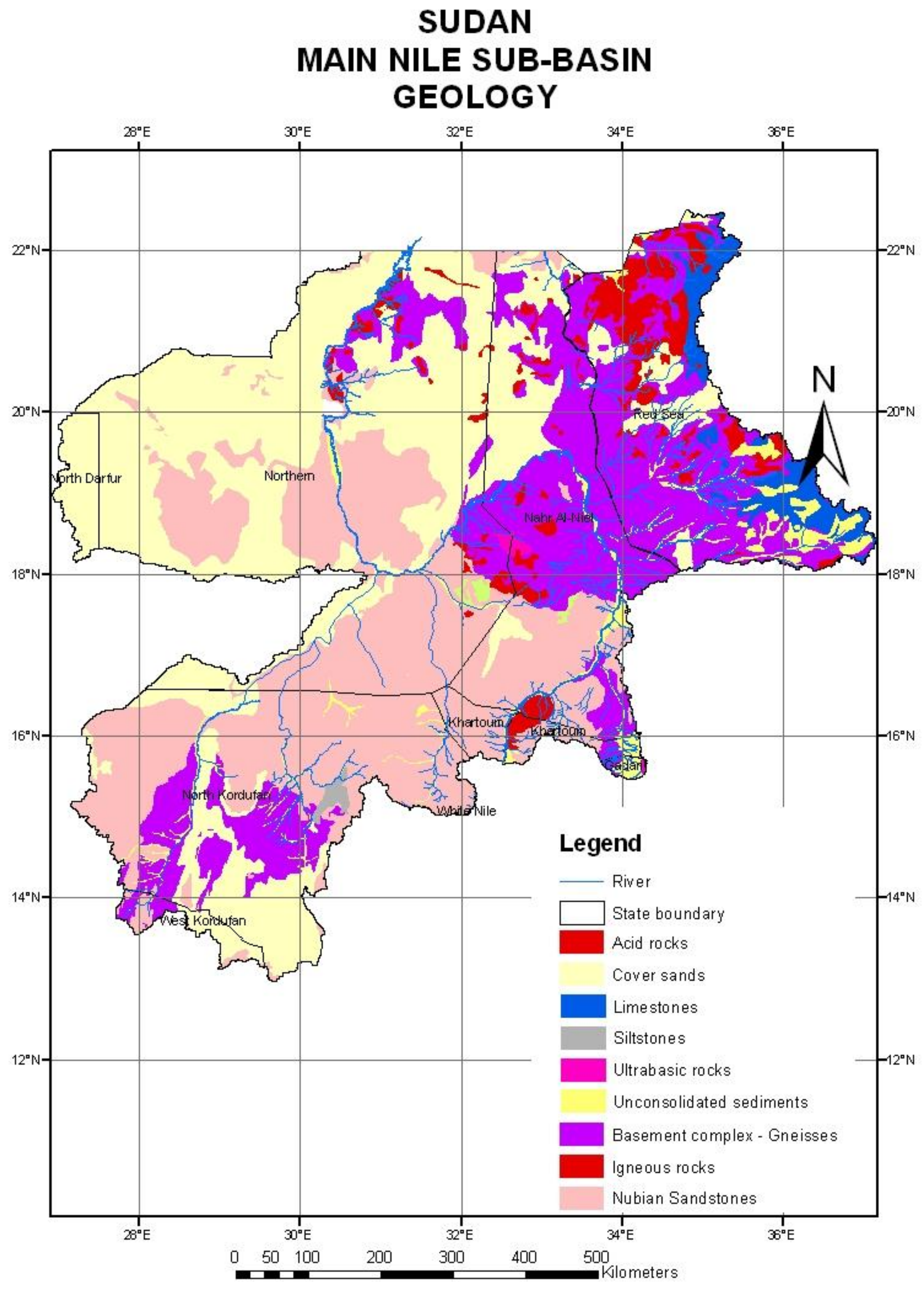
Source: CRA Sudan Report (2006)

Figure 5.16 : Main Nile: Mean annual temperature

5.3.4 Geology and Soils

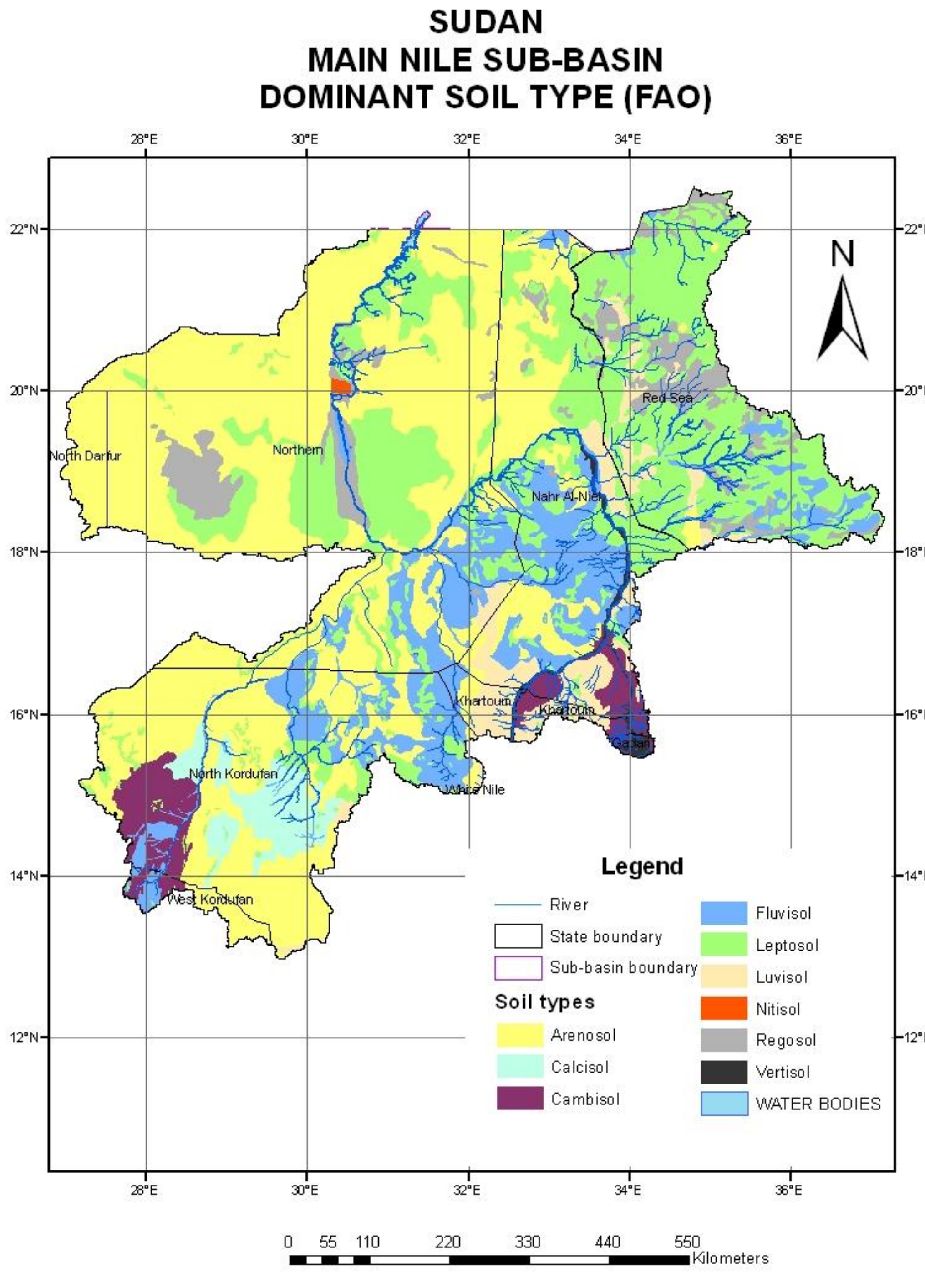
The main underlying geological formations within the Main Nile sub-basin include the Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands (Figure 5.17). The Basement Complex comprises gneisses, schists, marbles and intrusive granites and basic rocks. The Nubian Sandstones overly unconformably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates. This formation forms the main groundwater basins in Sudan.

The Recent deposits include Nile alluvium, sand dunes and the black clays of the flood plains. It is the long and usually narrow reach of the alluvial deposits along the Main Nile (barely depicted in Figure 5.17 because of map scale) which is the principal focus of attention for considering impacts of regulatory storage projects in Ethiopia. The narrow band of Vertisols and Fluvisols along the Nile is more evident in the soils map, Figure 5.18.



Source: CRA Sudan Report (2006)

Figure 5.17 : Main Nile: Geology



Source: CRA Sudan Report (2006)

Figure 5.18 : Main Nile: Soils

5.3.5 Land Cover and Cultivation

The topography and the extreme climate of the Nubian Desert cause the permanent vegetation to be restricted to a narrow strip of alluvial soils on each bank of the river and in khors, wadis and depressions. The overall picture is that the riverine flora is rich and diverse, often characterized by patchiness and fragmentation of habitats. The following description is based on areas north of Dongola but provides a general summary of land cover conditions along most of the alluvial soils of the Main Nile.

Riverine Vegetation

The riverine vegetation occupies the banks of the Nile and the land in front of cultivated ground. The riverine vegetation is predominantly trees and large grasses whose presence is directly dependent on the Nile. The date palms (*Phoenix dactylifera*) and acacias of this zone are undoubtedly the most conspicuous vegetation feature of many of the reaches where they often form a more or less conspicuous strip along both banks.

Of the Acacias the most abundant is *Acacia nilotica. A. tortilis* and *A. ehrenbergiana* and sometimes *A. seyal var fistula* and *Mimosa tementosa* occur at some higher levels on the banks. Where trees have been cleared, *A. nilotica* is often regenerating passing through a shrub phase. A few specimens *of A. tortilis* and *A. ehrenbergiana* are also found on rocky and sand banks.

Patches of *Tamarix sp., Salix sp*. and *Phragmites sp*. occur at some lower levels on the silt banks of the Nile particularly where there are gaps in the tree cover just outside the *Acacia nilotica* zone.

Generally the date palms (*Phoenix dactylifera*) tend to occur at higher levels on the banks and thus formed an indistinct zone inside the Acacias, although at times they are found at the water edge.

Much of the ground under the trees is bare or has a sparse herb layer in which *Cynodon dactylon* predominates. However, under the Acacias there are usually small numbers of rather stunted plants or seedlings of weeds typical of cultivated or disturbed ground (e.g. *Solanum incanum, Calotropis procera, Rhyncosia minima, Tephrosia apollinea* and *Desmostachya sp*.).

Permanent Cultivation

The alluvial cultivated strips are bordered by vast sterile rocky-sandy desert on both sides of the Nile. In the Dongola - Kerma area, cultivated land is the largest and most fertile in the Nubian region. Here the land suitable for cultivation extends outwards to some 3 - 4 km.

Permanent cultivation tends to be situated on the silt between the riverine vegetation and houses at the desert edge. Irrigable land occurs sometimes on both adjacent banks; elsewhere, it is restricted to either left or right banks. The main crops beside date-palm are *Vicia faba* (broad beans), *Triticum sp.* (wheat), *Lupinus termis (*turmus*), Medicago sativa (*bersim*), Allium cepa* (onion) and a variety of vegetables.

Water for irrigation is raised from the Nile by pumps and is led along irrigation canals to the fields.

Virtually all the original or natural vegetation is cleared for cultivation although a few trees of *Hyphaene thebaica, Tamarix sp*. and Acacias (usually *A. nilotica* and *A. tortilis*) can be seen within this zone. The natural vegetation of the cultivation is almost entirely composed of weeds widespread in irrigated areas in Sudan.

The permanent irrigation ditches usually support well-developed and probably permanent vegetation on their silt embankments. They are normally covered by the common typical weeds like *Euphorbia hirta* and by the grasses - *Cynodon dactylon, Desmostachya sp*. and *Echinochloa colonum*.

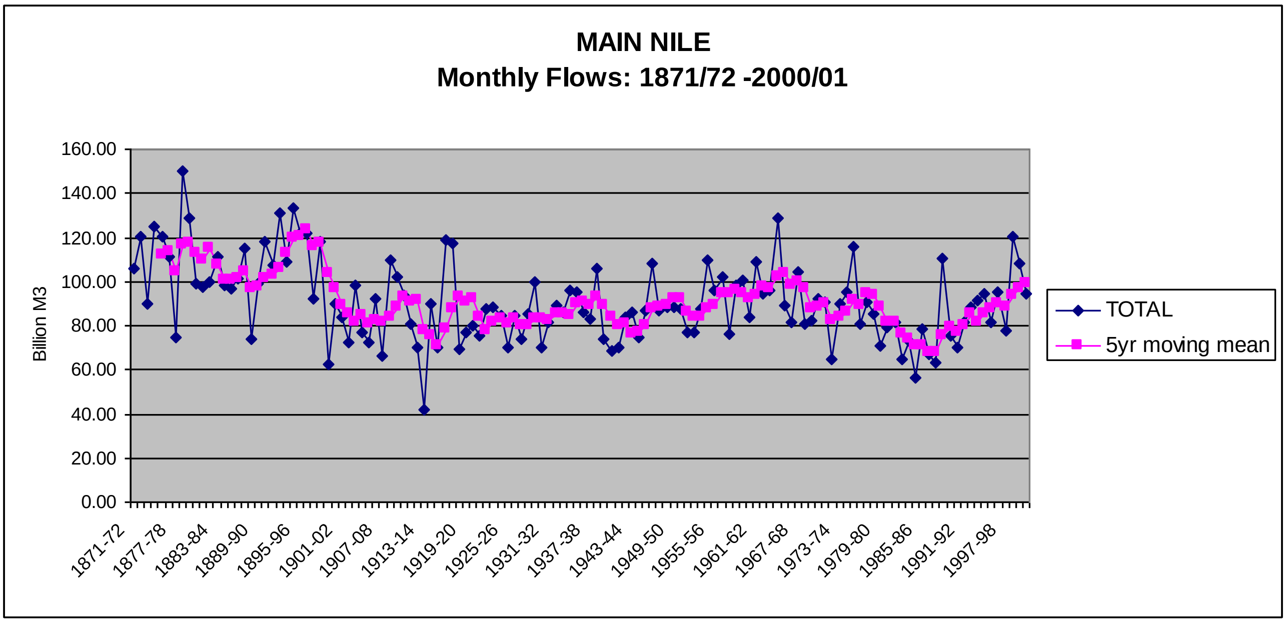
Vegetation in Wadis, Khors and Desert Hollows

The only signs of life away from the riverbanks occur in wadis and khors leading to the Nile. These contain a number of shrubby perennials near the river where the sediment in the Khors is thickly deposited. It seems reasonable to assume that the roots of these plants reach the water table of the Nile. Typically, the khors and wadis contain: *Acacia ehrenbergiana, A. tortilis, Calotropis procera Desmostachya bipinnata, Leptadenia pyrotechnica, Tamarix spp., Colocynthis vulgaris, Aerva sp., Cassia spp., Euphorbia granulata, Fagonia sp., Pulicaria crispa*, and *Tribulus terrestris.*

An assessment of the area of the riverine vegetation and cultivated areas alongside the river supported by the Nile's annual flood is introduced in Section 5.6.

5.3.6 Surface water resources and sediment transport

The mean annual flow of the Main Nile at the border with Egypt, after ephemeral inflows and losing some water to evaporation along the reach of more than 1,500 km from the confluence of the Blue and White Niles in Khartoum, has historically been taken (before any significant abstraction) as 84 billion m^3 (1905-1959). However, there are considerable year-on-year as well as periodic variations (Figure 5.19).



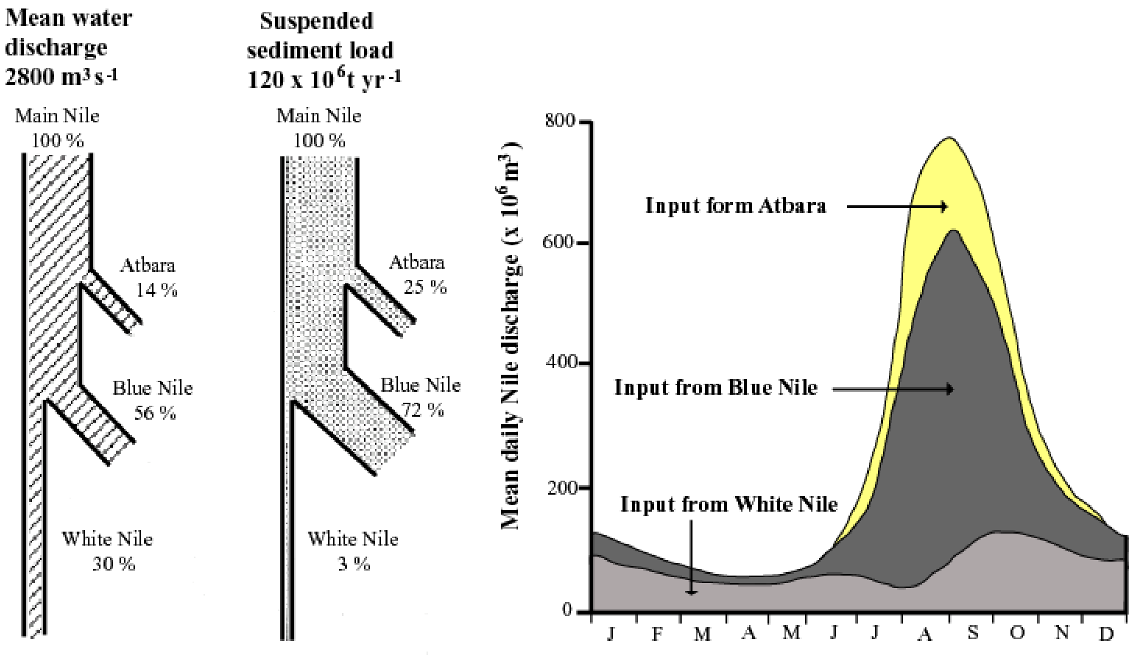
Source: CRA Egypt Report (2006)

Figure 5.19 : Main Nile: Annual Discharges and 5 year moving mean

From 1871 to 1896 there was a period of high flows; high lake levels occurred across East Africa. Between 1901 and 1975 annual discharges averaged around 87 billion m^3. However, the drought year of 1913 within this period is seen to have the lowest discharge in the entire record. The decade from 1976 to 1987 produced a series of very low flows – average annual flow about 76 billion m^3, since when flows have increased again.

Estimates of sediment transport have been made for the Merowe hydropower project located approximately half way between Khartoum and Lake Nubia. Estimates of mean annual sediment load are reported to range between 120 and 143 million tons.

The average annual suspended sediment entering Lake Nubia is estimated to be 120 million tons of which 72% is from the Blue Nile, 25% from the Atbara and only 3% from the White Nile (Figure 5.20).



Source: CRA Egypt Report (2006)

Figure 5.20 : Mean Discharge and Suspended Sediment Load for the Nile Basin

The concentration of suspended sediment entering Aswan High Dam Reservoir also has a seasonal variation similar to the flow hydrograph. However, the peak discharge and peak suspended sediment concentration do not occur simultaneously. The suspended sediment concentration rises to a maximum (5,000 ppm) many days before the peak of water discharge. The lag time between the peak of the water discharge and the suspended sediment concentration varies from year to year, and on average is approximately 10 days.

Various estimates of sediment inflows, deposition and outflows have been derived. The following account is taken directly from the CRA Main Nile Sub-Basin Report (January 2007).

Shalash (1980) estimated an average annual rate (1958-1979) of sediment inflow of 130 million tons, outflow of 6 million tons and a net sedimentation rate within the reservoir of 124 million tons. Two years later, Shalash estimated the total annual inflow as 142 million tons, the average rate of outflow as 6 million tons with a net sedimentation within the Lake of 136 million tons. Using an average sediment density of 1.56 g cm^{-3} and corrected for compaction (dry weight density of 2.6 g cm^{-3} and a porosity of 40 %), the amount of annually retained sediment of 136 million tons of suspended sediment corresponds to an accumulated volume of 87 million m^3 per year (Shalash, 1982).

El-Moattessem and Makary (1988) using sediment and discharge data from Dongola from May 1964 to December 1985, estimated the total volume deposited within the

Lake as 1,657 million m^3 or 75 million m^3 per year. Using the Shalash conversion factor this is equivalent to 117.2 million tons per year. The calculated volume for the same period from the hydrographic survey was 1,647 million m^3, very close to the estimated figure. At this rate the dead storage capacity of 31.6 billion m^3 would be lost in 420 years (close to the design life of 450 years).

El-Manadely (1991) and Abdel-Aziz (1991) used a one-dimensional model and estimated the total volume of deposits in the reservoir between 1964 and 1988 at 2,650 million m^3 or 106 million m^3 per year. Dead storage would be lost in 300 years at this rate of sedimentation.

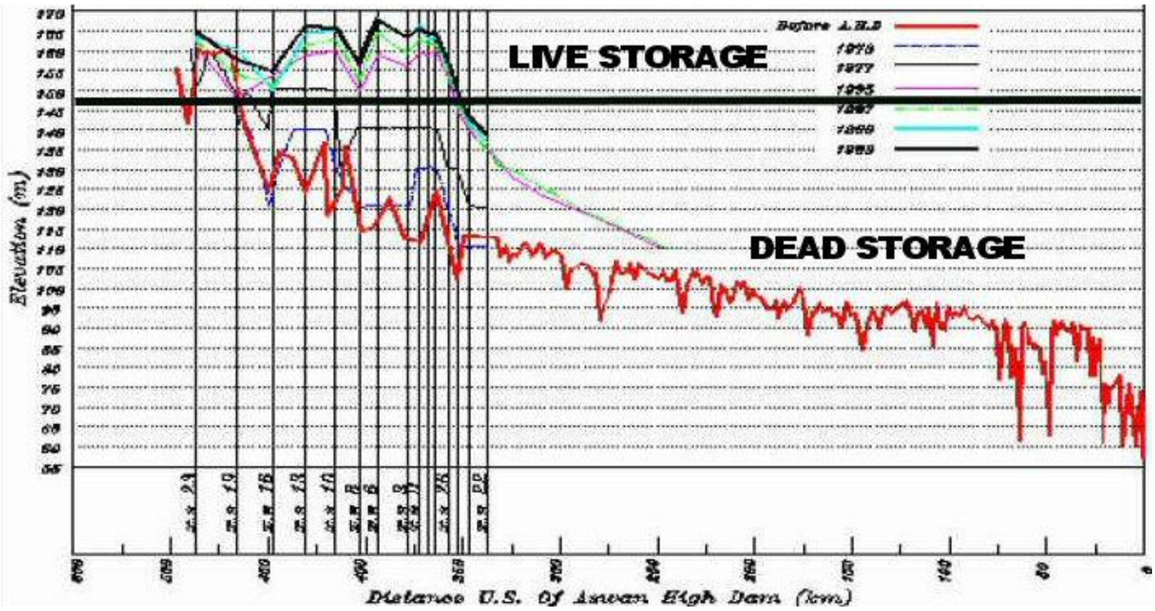
Based on sedimentation data over a 5-year study interval between 1987 and 1992 by Eldardir (1994), a sediment volume of 119 million m^3 per year was estimated to be annually deposited in the AHD Reservoir. This is equivalent (using Shalash's conversion factors) to 186 million tons per year (for the study period). This result implies that after the 41 years since the AHD closure in 1964, the reservoir has lost ~ 11 % of its dead storage capacity (~ 0.3 % annually). At this accumulation rate the dead storage capacity (is used) in 360 years.

It may be noted that if we take Eldardir’s 119 million m^3 per year (186 million tons per year) as the new baseline sedimentation rate from 1992 (and note that it was a five-year average established 15 years ago), and if we adopt the remaining dead storage capacity as 28.1 billion m^3 (i.e. 31.6 billion m^3 minus 11%), the remaining dead storage of HAD would be lost in 236 years at this new baseline rate of sedimentation. This presents a very different outlook compared to the statement “At this accumulation rate the dead storage capacity (is used) in 360 years”.

The CRA report points out that it is important to note that there is considerable annual variation in sediment load, ranging between 50 and 228 million tons. However, here we may note that the mean rate for the 5-year study period between 1987 and 1992 was estimated at 186 million tons per year, i.e. near the top end of the range quoted.

Surveyed longitudinal bed elevations of Aswan High Dam are shown in Figure 5.21. It is noted that siltation is taking place in both the dead and live storage zones, and is moving progressively downstream.

The increasing rates of sedimentation at HAD appear to firmly support our concerns expressed about the inadequacy of sediment transport data at Kessie, Border and El Deim in Chapter 4, believing that sediment transport rates of the Abbay are currently much higher than previously estimated.



Source: CRA Egypt Report (2006), from El-Moattassem *et al* (2005)

Figure 5.21 : Longitudinal bed elevation profile for Aswan High Dam Reservoir

5.3.7 Groundwater

Four categories of ground water basins have been recognized based on the geological formations.

i) fractured/weathered Basement Complex aquifers
ii) Nubian sandstone basins
iii) Detrital Quaternary-Tertiary basins
iv) Recent Alluvium basins

Groundwater storage along the Main Nile course relates to the Nubian sandstone and Recent Alluvium basins.

The Nubian sedimentary formation forms the most extensive and largest ground water basin in Sudan. Although recharge from rainfall is limited, an annual amount of 1,074 million m^3 is received from the Nile river system. This is equivalent to 34 m^3/s. The quality is good to excellent with salinity values rarely exceeding 600 mg per litre.

The alluvial basins are located along most seasonal streams and are recharged from rainfall and seasonal storm runoff, and along the Main Nile particularly from annual overbank flood flows. Water quality is generally good.

Discussions with residents in the Bayuda area, north of Dongola, emphasised the importance of wells and mataras for domestic water supplies, and noted how the performance and quality of some wells can deteriorate following extreme flooding, as in 1988. An example was given of an important well turning from “sweet” to “bitter” after the 1988 flood, a curious and unexplained phenomenon.

5.3.8 Administration

The Main Nile sub-basin in Sudan encompasses eight Administrative Regions (Table 5.8).

Table 5.8 : Main Nile: Administrative Regions

Region	Area (km^2)	% of Sub-basin
North Dafur	9,788	**1**
North Kordafan	139,636	**21**
West Kordafan	7,220	**1**
Northern	259,180	**39**
Khartoum	13,663	**2**
Nile	118,500	**18**
Gadarif	1,654	**0.3**
Red Sea	111,236	**17**
SUB-BASIN	660,877	**100**

The administrative regions through which the Main Nile flows, and will receive impacts from storage developments in Ethiopia, are Khartoum, Nile and Northern (Figure 5.22). The Lake Nasser Governate is shown in Figure 5.23.

5.3.9 Population

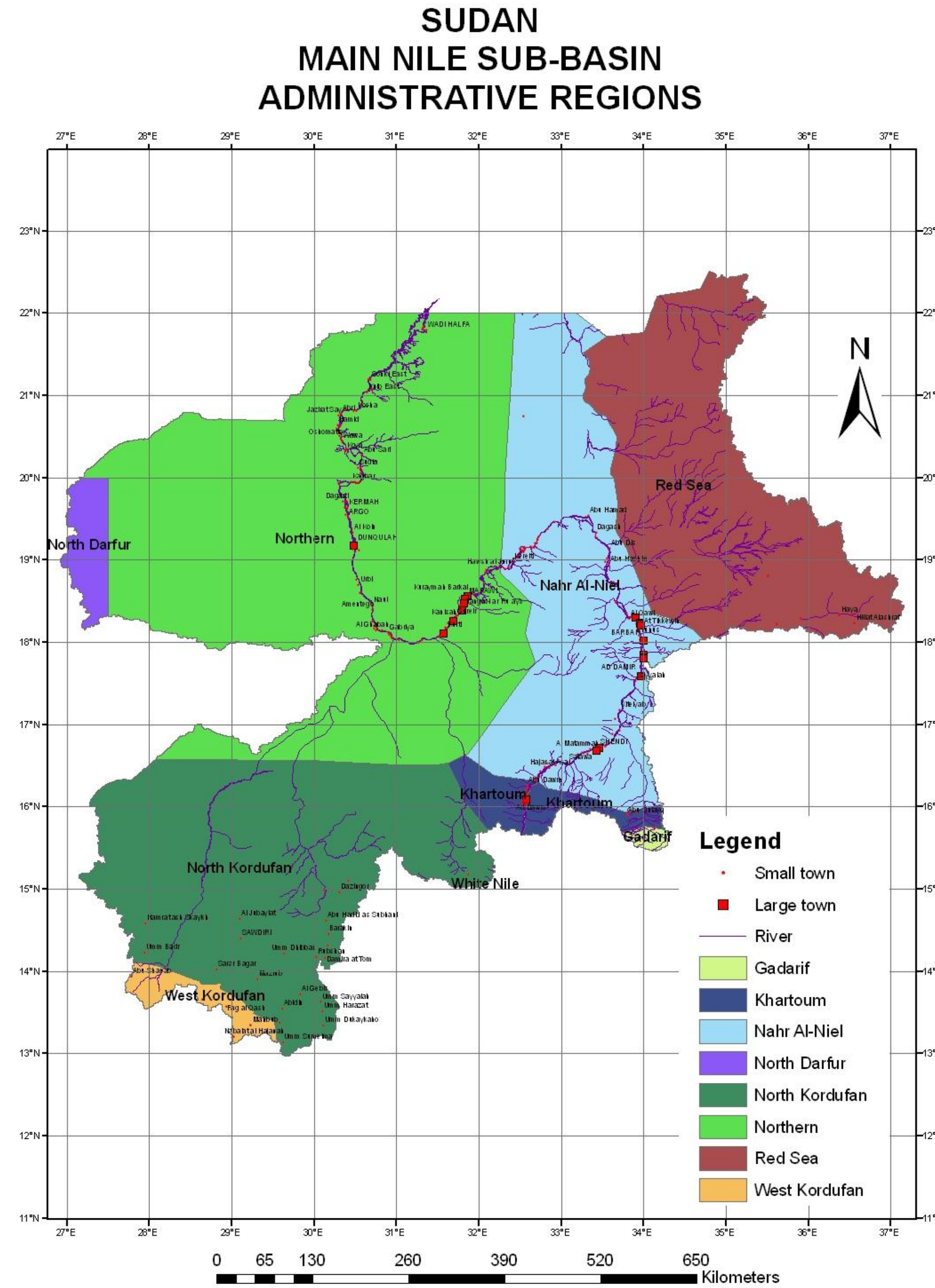
The population of the States contained mainly within the Main Nile Basin are shown in Table 5.9. About half of this population is in Northern and Nile regions and may be considered to be totally dependent on the Nile for both water and food supplies where flood recession agriculture and irrigation schemes use Nile water.

Table 5.9 : Population of States within Main Nile sub-basin

Northern	1,179,399
Nile	701,256
Red Sea	2,048,041
TOTAL	**3,928,696**

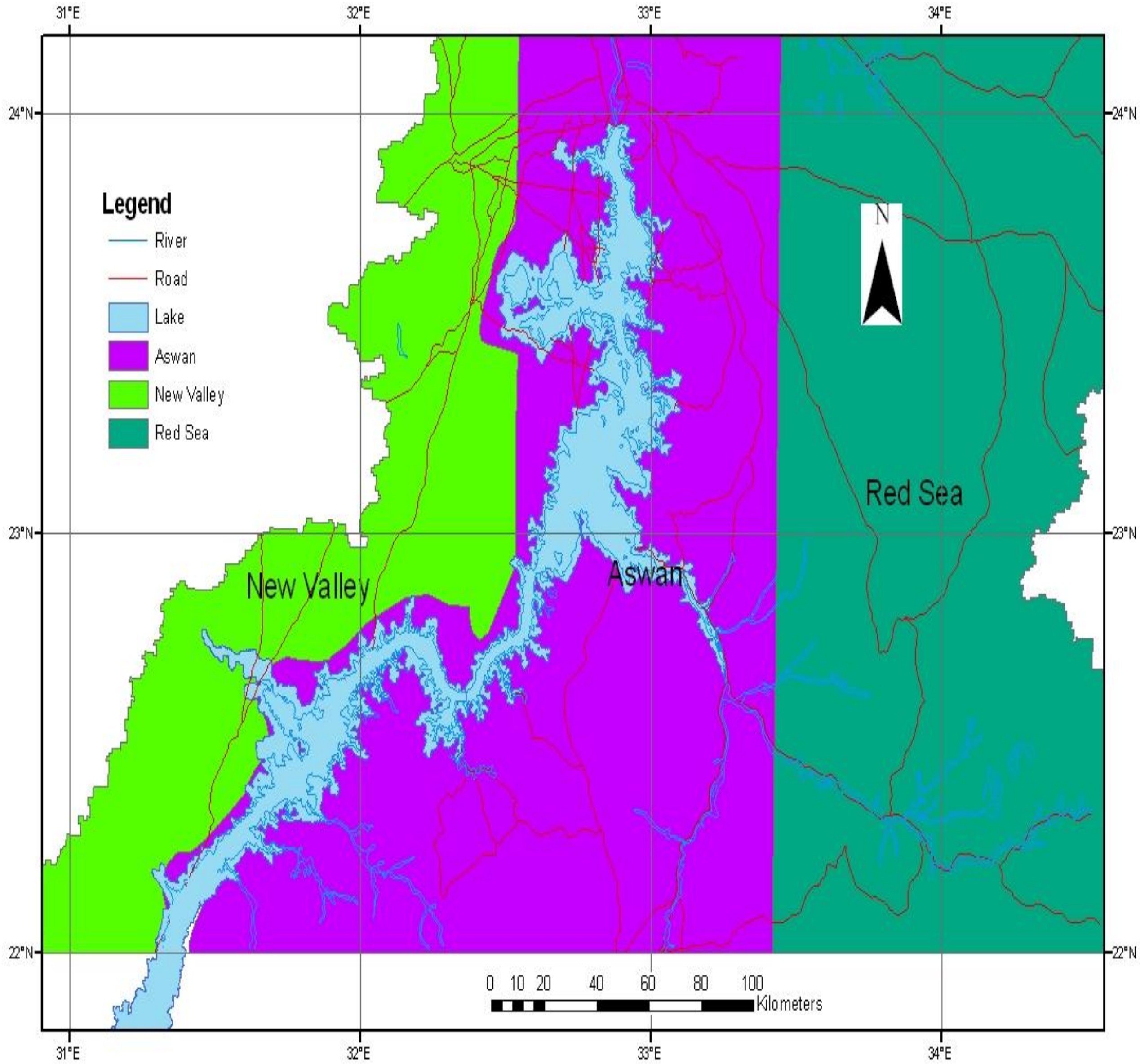
Source: CRA Sudan Report (2006)

The main areas of high population density along the Main Nile are north of Khartoum and in the areas around Atbara, Karima/Merowe and Dongola. Away from villages and towns along the Nile’s fertile alluvial strip, with few exceptions, densities are typically zero. Population density for the Main Nile in Sudan is shown in Figure 5.24, and for the Lake Nasser Governorate in Figure 5.25.



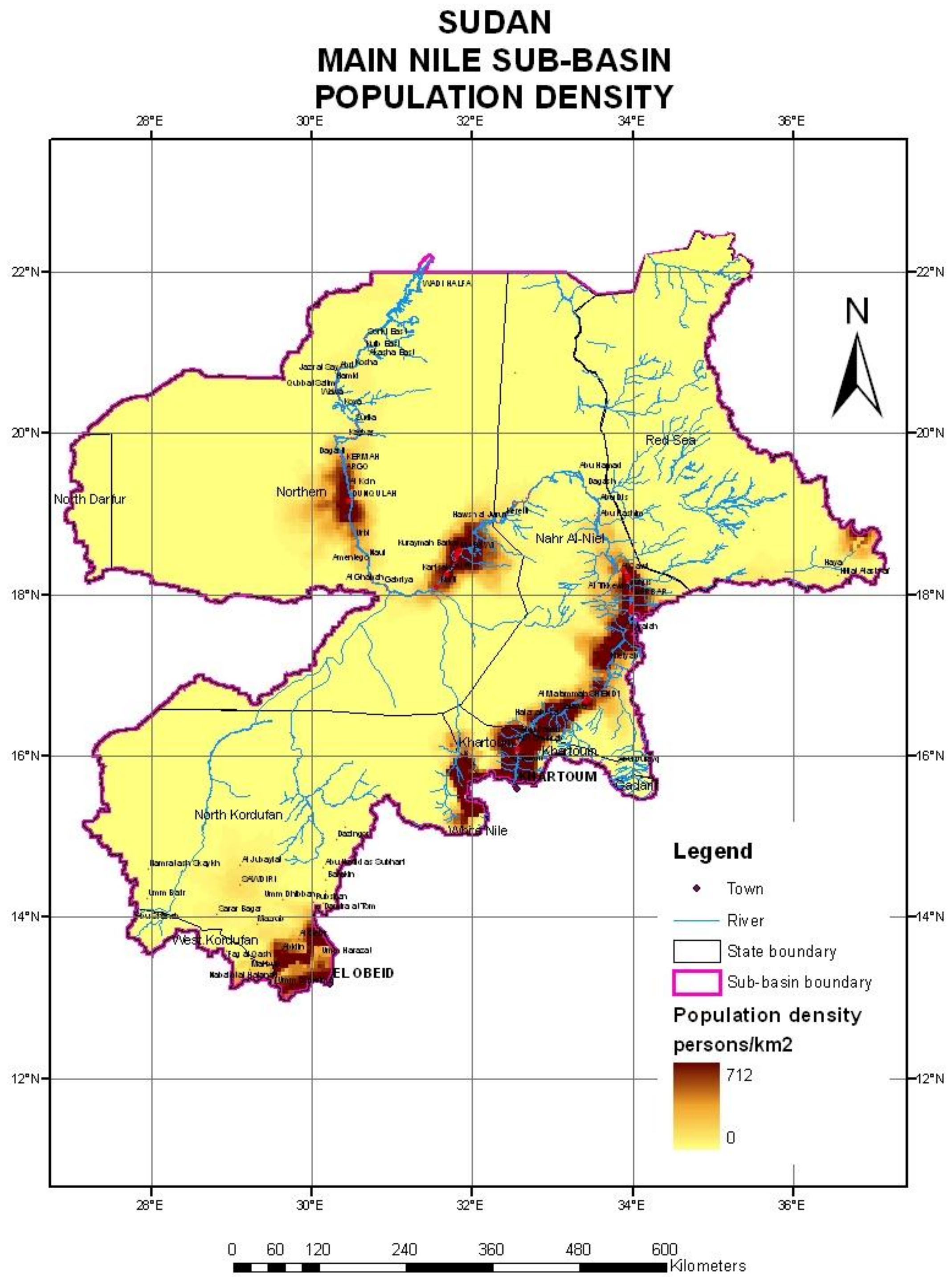
Source: CRA Sudan Report (2006)

Figure 5.22 : Main Nile: Administrative States



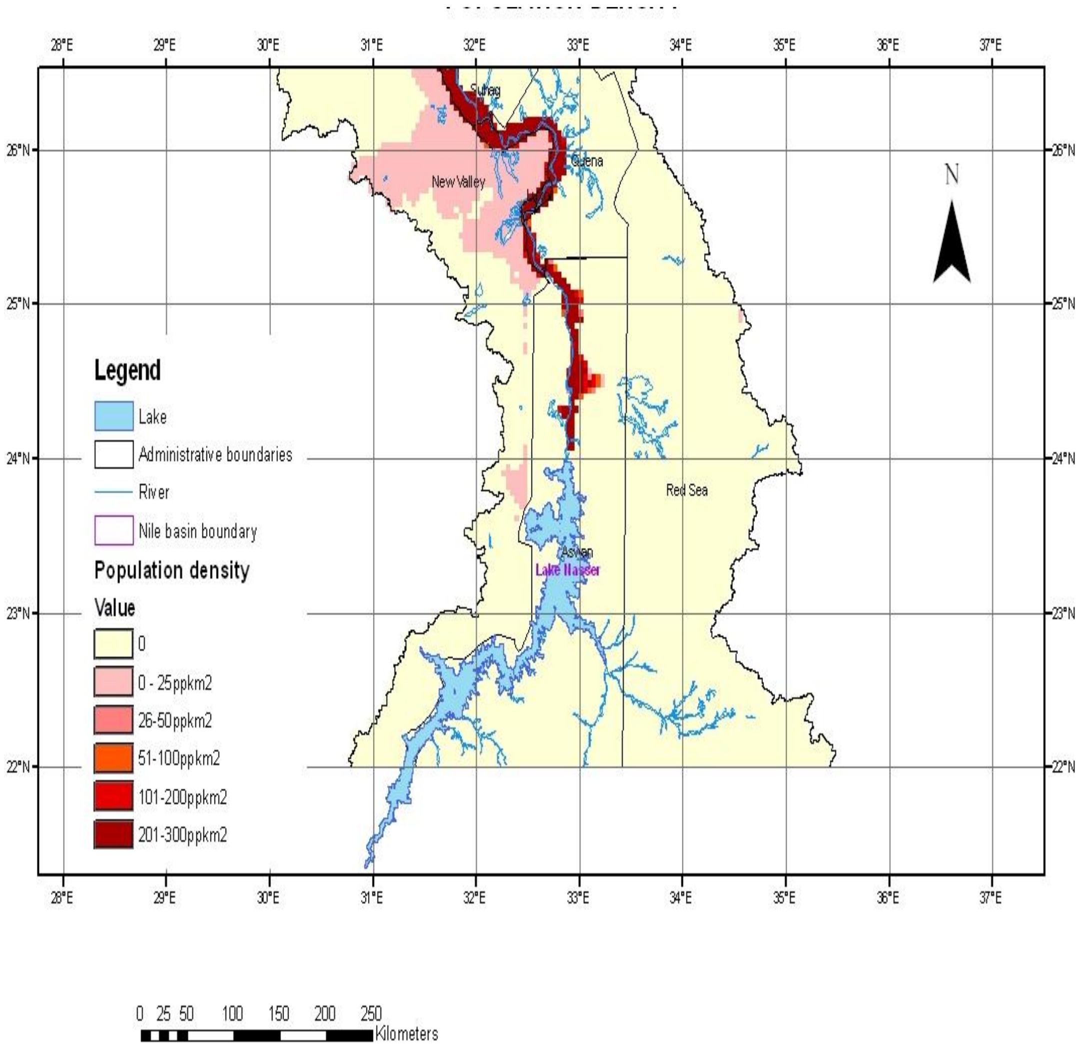
Source: CRA Egypt Report (2006)

Figure 5.23 : Egypt Lake Nasser Governorate



Source: CRA Sudan Report (2006)

Figure 5.24 : Main Nile Sub-basin: Population density



Source: CRA Egypt Report (2006)

Figure 5.25 : Main Nile: Population density in Lake Nasser Governorate

5.3.10 Demographic Characteristics

Demographic characteristics are given in Table 5.10. Population growth rates are low, between 0.52 and 1.9% per annum. There is high youth emigration, particularly to Khartoum and the Gulf countries.

Table 5.10 : Main Nile Sub-basin: Demographic Characteristics

State	Growth rate %	Urban %	% <15 yrs	% >60 yrs	Sex ratio M/F	Crude birth rate	Crude death rate	Infant mort. male*	Infant mort. female*
Northern	1.70	15.2	39.7	5.9	94.7	37.8	11	116	98
Nile	1.90	33.7	41.0	5.3	97.6	34.0	10.8	108	90
Red Sea	0.52	60.5	38.5	4.3	116.1	34.7	9.7	95	88
North Kordofan	1.60	31.1	47.4	4.3	91.8	40.1	12.2	125	106
NORTH SUDAN	2.8	37.3	42.8	4.1	100.4	37.8	11.0	116	98

* per 1000 live births

Source: CRA Sudan Report (2006)

5.3.11 Literacy and Education

Literacy and primary school enrolment rates are shown in Table 5.11.

Table 5.11 : Main Nile Sub-basin: Literacy and Primary School Enrolment

State	Literacy >15yrs % Average	Literacy >15yrs % Male	Literacy > 15yrs % Female	Population 6-13yrs	Total Primary school enrolment	% enrolment
Northern	65.2	75.0	56.6	114,040	100,336	88.0
Nile	64.5	73.6	56.5	186,851	147,477	78.9
Red Sea	47.9	54.5	40.1	154,210	69,290	44.9
North Kordofan	39.1	52.0	29.4	364,719	170,023	46.6
NORTH SUDAN	**54.5**	**66.6**	**42.4**	**6,493,230**	**3,308,387**	**51.0**

Source: CRA Sudan Report (2006)

There are very clear differences in literacy and primary school enrolment rates between Northern/Nile States and Red Sea/North Kordofan States, with the former considerably above the Northern Sudan average. Female rates are below those of males.

5.3.12 Water Supply and Sanitation

The proportion of population (%) with access to drinking water and sanitation facilities is shown in Table 5.12.

Table 5.12 : Main Nile Sub-basin: Access to Water, Sanitation Facilities

(a) Drinking Water by Source

State	Main source of water							
	Piped into Dwelling	Public tap	Deep Well/pump	Dug Well/ bucket	River/canal	Rainwater	Others	Missing
Northern	50.8	4.3	15.8	9.8	12.8	--	6.4	0.1
Nile	42.3	3.7	12.2	13.5	24.7	--	3.4	0.2
Red Sea	25.6	18.3	28.3	25.8	1.5	--	0.5	--
North Kordofan	16.3	5.3	20.5	25.4	2.2	13.2	17.1	--
NORTH SUDAN	**50.8**	**4.3**	**15.8**	**9.8**	**12.8**	**--**	**6.4**	**0.1**

(b) Sanitation facility by type

State	Flush to Sewage System	Flush to septic tank	Traditional pit latrine	Soak away pit	Others	Missing	No facilities
Northern	--	7.7	69.2	1.6	1.6	--	19.9
Nile	--	12.3	72.6	0.7	0.7	0.1	13.5
Red Sea	--	20.9	26.1	4.2	0.7	0.2	47.9
North Kordofan	--	2.9	31.4	1.9	1	0.1	62.6
NORTH SUDAN	--	7.7	69.2	1.6	1.6	--	19.9

Source: CRA Sudan Report (2006)

A similar distinction between Northern/Nile States and Red Sea/North Kordofan States is apparent with respect to water and sanitation facilities. The two former States are well above the national average with respect to piped water and sanitation facilities.

5.3.13 Socio-cultural Aspects of population

There is considerable socio-cultural diversity among the population of the Main Nile sub-basin mirroring that of the whole of Sudan. The following description is a brief summary of a complex picture and lists only the larger socio-cultural groups.

The main groups are Nubians, Danagla, Bedirya and Rekabia. Along both banks of the Nile itself are the Gaa'lian people who have inherited the rights to use their land and being closest to water were able to survive the devastating drought of 1983/84. Also living both sides of the river are the Shaigia, Kawahla, Kababish and Hassaniya peoples, mainly pastoralists but who also cultivate sorghum along the wadis. As with all the pastoral/agro-pastoral groups wage labour is a major feature of livelihood strategies. Living mainly along the Wadi Muqadam and more recently along the Nile below Korti are the Hawaweer people. Their livelihoods too were devastated by the 1983/84 drought but many have returned and rebuilt their livelihoods.

5.3.14 Transport

Over much of the basin the road network is very poor given the vast expanse of desert (Figure 5.26). There are two primary (asphalt) and some all-weather secondary roads:

(a) Primary Roads

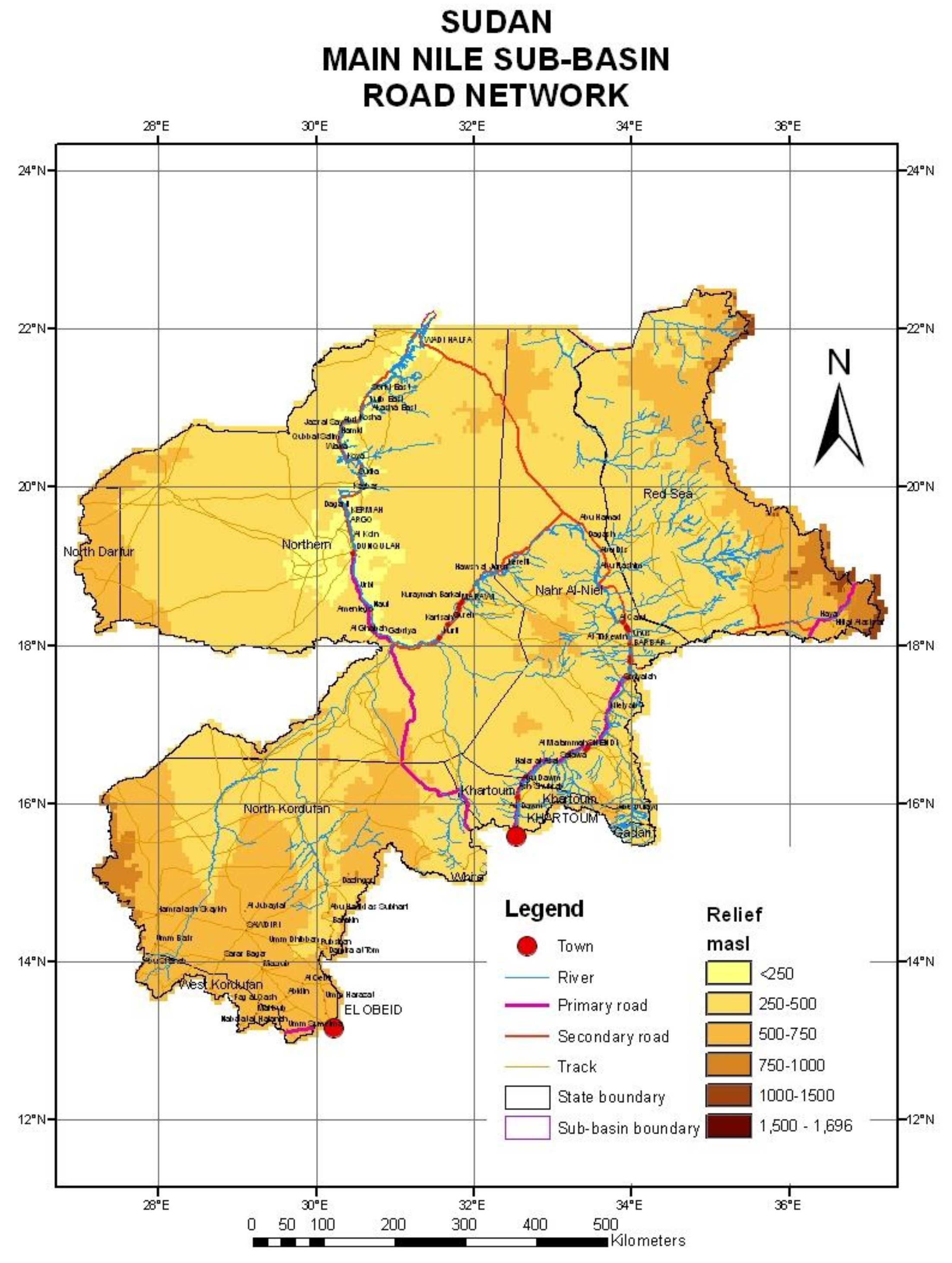
Khartoum - Atbara (312 km) and Atbara – Haiya (under construction)

Khartoum - Abu Dom (386 km) and Abu Dom – Dongola (under construction)

(b) Secondary Roads

Atbara-Wadi Halfa (613 km). Other roads are generally in poor condition. On clay plains, they are often impassable during the rains.

There is one rail line: Wadi Halfa – Khartoum.



Source: CRA Sudan Report (2006)

Figure 5.26 : Main Nile: Road Network

5.3.15 High Aswan Dam

"Egypt is the gift of the Nile", wrote the Greek historian Herodotus in the fifth century B.C. No other country owes its very existence to a single lifeline" (El-Sayed and van Dijken, 1995). The runoff from the rainfall in East Africa caused the annual summer flood of the Nile that the Egyptians depended on for water to irrigate their crops, and deposit fertile topsoil. This annual flood was the major reason that the areas surrounding the Nile became habitable. But at the turn of the 20th century the growth of population had well exceeded agricultural production. The Nile had to be controlled if there was going to be agricultural stability along its banks.

The first of the dams was the Aswan Dam. This was completed in 1902, constructed 5 km upstream of the city of Aswan. It was the chief means of storing irrigation water for the Nile valley. The Aswan Dam's height was raised in subsequent building campaigns of 1907-12 and 1929-34. Even after these campaigns, it was necessary to open the sluices to release flood inflows. This caused tremendous amounts of damage downstream, flooding the areas that were supposedly protected. It was then decided that a second, larger and more effective dam was necessary. In the early 1950s, designs began to be drawn for what was to become the High Aswan Dam. The construction of the Aswan High Dam had many effects on Egyptian life, agriculture, and the environment (Schall, 2001).

The High Aswan Dam supported a very high population growth rate because it expanded agriculture, energy, and manufacturing production. Lake Nasser became an important fishing site, supplying food and providing livelihoods for the population around it (Dubowski, 1997). Also, the agriculture and farming industry of Egypt was also directly impacted by construction of the Dam. There were positive and negative impacts.

One of the positive impacts on agriculture was that crops could be grown year round. The High Dam created a 30% increase in the cultivable land in Egypt.

The formation of the artificial lake known as Lake Nasser/Nubia extended nearly 500 km to Dal cataract, with a width in places of 10 to 25 km. The potentially cultivable area around the lake is almost one million feddan. Generally speaking, most of the new lands are calcareous or sandy, or both (Hanna and Osman, 1993). The main reclaimable areas around Lake Nasser are located on the east bank of the lake in Wadi El-Alaki and Wadi El-Targi. Those on the west bank are found in Wadi Kurker, Kalabsha, Dekka, Marwa, Toshka, Abu-Simbel, Khor Sara, Tomas and Affia (Desert Research Centre, 2005).

As part of the national strategy to combat poverty, it is reported that the Government of Egypt plans to settle approximately one million people on reclaimed desert in the area around Lake Nasser by the year 2017. Despite widespread support for this goal, experience shows that new settlers are highly vulnerable to hardship and that the impact of new settlements on the environment can be adverse. Research projects aim to develop sustainable strategies for improving the socio-economic conditions, health and livelihoods of poor and marginalized settlers living in fragile ecosystems.

5.3.16 Lake Nasser Area

The area around Lake Nasser is desert characterized by its very dry and hot climate. Temperatures are very high in summer and moderately low in winter. Rainfall is very rare and erratic and absent for long periods exceeding ten years in some cases. Heavy showers causing sizeable damages are sometimes experienced. The soil is gravely sand and sandy clay at the edges of the lake. Natural vegetation cover is almost absent because of the climatic and soil characteristics of the area except for the very narrow strip parallel to the lake banks and its extensions that narrow and widen according to the topography and the seasonal reservoir level.

In 1963, the Government of Egypt established the Aswan Regional Planning Authority (ARPA) to plan and implement the development of Aswan Governorate following the completion of the High Dam. A research function was added in the mid-1960s based on recommendations from the United Nations Development Program (UNDP). In collaboration with the Food and Agriculture Organization of the United Nations (FAO), UNDP was assisting several African governments to establish research organizations on new man-made lakes. In 1966, UNDP's Governing Council approved a similar request from Egypt to establish a "Lake Nasser Development Centre" which became operational in July 1968 for a six-year period.

Development-relevant research activities included agriculture, fisheries, public health, settlement planning, tourism and transportation. A final report was issued in 1975 on project findings and recommendations. Subsequently a High Dam Development Authority (HDDA) was established to develop the lake region. Planning has continued into the present century, with socio-economic plans for the Aswan area and the reservoir being prepared with UNDP assistance during the 2000-2004 period.

Agriculture and Settlement

It is reported that sand has encroached on the Dam Authority farm in Abu Simbel area. On the Egyptian side of the lake there is no serious sand dunes movement problem but drifting sand is blown into the lake. The Dam Authority in collaboration with the Environment Research Institute is undertaking some research studies on wind speed, sand dunes movements, types and quantities of sand, estimates of sand volumes which are deposited into the lake using sand traps in 12 stations on the western side of the lake where there are active sand movements. It has been estimated that the moving sand is $700m^3/km$ annually and that 125 million tons are blown into the lake annually. The impact of this is reduced storage capacity of the lake and barrages downstream. (Thus, these 125 million tons/year are in addition to sediment transport received from Nile inflows).

Hot desiccating winds have direct negative effects on agricultural production because of their physiological and mechanical effects on crops.

This is therefore a climatically hostile environment for developing irrigated agriculture, shelterbelts and farming settlements but these are objectives of past and ongoing research in order to relieve Egypt's high population density along the Nile downstream and in the delta and to make beneficial use of reservoir water locally.

Under a UNDP/FAO project, a research station was built near Abu Simbel and several kilometres inland from the reservoir to experiment with different crops in the reservoir drawdown and inland areas. Though requiring use of fertilizers, large areas, especially around reservoir inlets, were identified with agricultural potential. These included areas requiring lift irrigation up to 30 metres above full storage level.

Below full storage level, it has been estimated that approximately 200,000 feddan could be cultivated during the winter months in short maturing crops “using mainly subsoil moisture” (i.e. utilising residual moisture as the Lake recedes) though supplementary irrigation would increase reliability of yields. Problems with this have been experienced when lake levels have unexpectedly risen, owing either to raised Nile inflows or changes in Aswan power station drafts. The most economic crops to grow without irrigation would be fodder crops and vegetables along with a wide variety of fruit trees along the reservoir margin. Further inland in the Toshka depression, 500,000 feddan were identified for pump irrigation. In view of escalating costs of pump irrigation to higher elevations and the extensive reservoir drawdown during drought years, these figures may be a significant over-estimate.

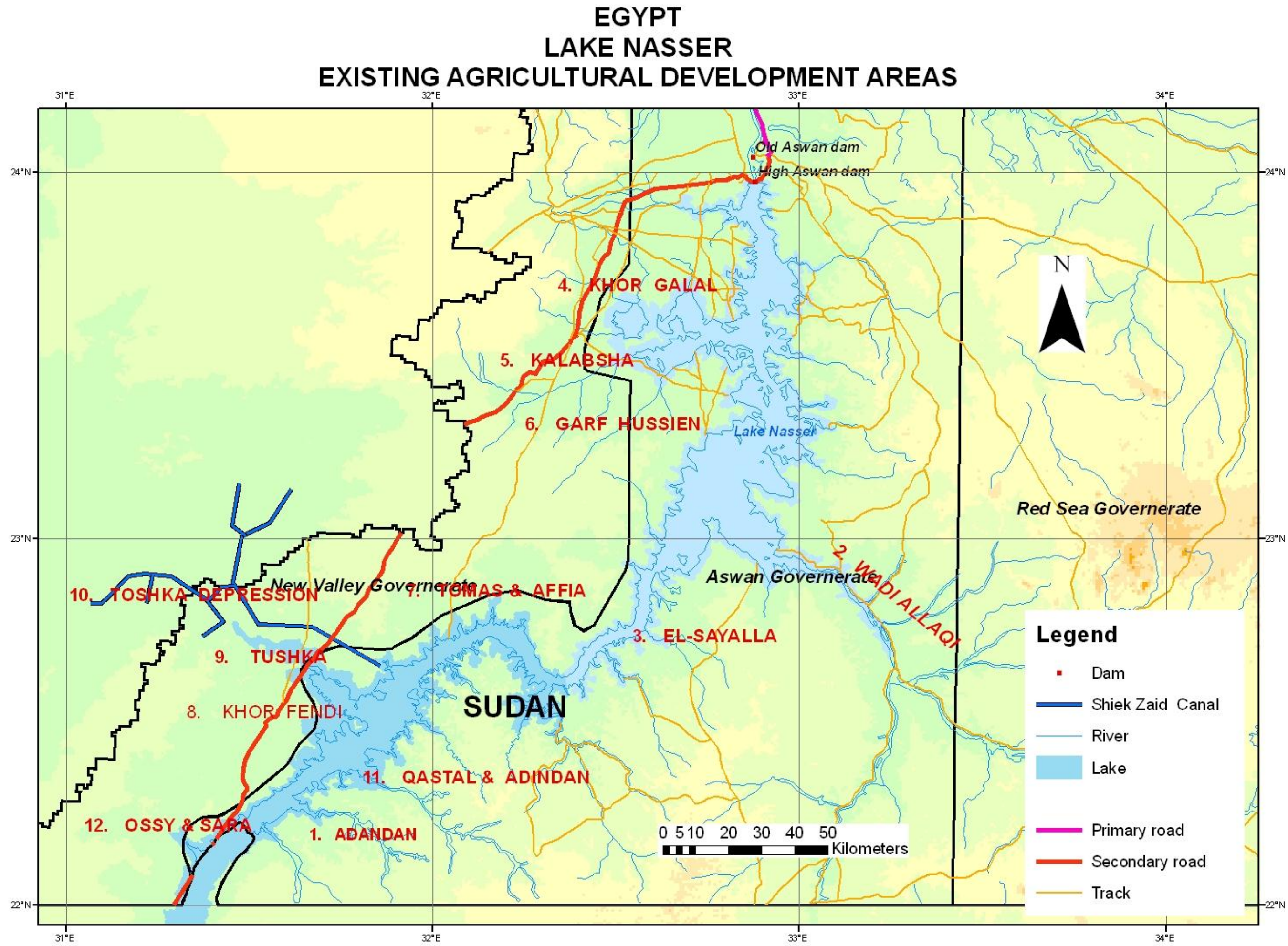
The most recent data (2006) regarding agriculture and farming around Lake Nasser show that the total agricultural area is 12,970 feddans, of which about half is cultivated and half is uncultivated. These areas are located around the lake as shown in Table 5.13 and Figure 5.27.

Table 5.13: Zones, group locations and cultivated areas on Lake Nasser shores

Location on Zone	Groups	Persons*	Agriculture area feddan		Total area feddan
			Cultivated	Uncultivated	
A. East	**53**	**159**	**1,073**	**900**	**1,973**
Dahmeet	1	3	40	-	40
El-Alaki	23	79	485	260	745
El-Sayalla	29	77	548	640	1,188
B. North	**166**	**471**	**3,357**	**835**	**4,192**
Khor Galal	15	54	335	37	382
Kalabsha	67	211	1,417	68	1,486
Garf Hussien	51	145	843	620	1,473
Tomas &Affia	33	70	742	110	852
C. South	**95**	**379**	**2,338**	**4,467**	**6,805**
Khor Fendi	32	134	577	1,070	1,647
Tushka	34	114	1,291	1,042	2,334
Tushka	10	43	429	2,100	2,529
Depression	19	88	41	254	295
Qastal &	-	-	-	-	-
Adindan					
Ossy & Sara					
Total	314	1,009	6,768	6,203	12,970

* Number of settlers

Source: CRA Report, Egypt (2007), from General Authority for Development of AHD Lake (GAD-AHD-Lake), 2006 (High Dam Development Authority), Agricultural Sector



Source: CRA Report, Egypt (2007)

Figure 5.27: Lake Nasser: agricultural development schemes

Some 4,000 feddan (about 60% of the cultivated area) were reported to be cultivated during the winter season of 2005/06. Plants grown as shore farming were field crops (551 feddans), vegetables (3,427 feddans) and medicinal/aromatic plants (16 feddans) as shown in Table 5.14.

Table 5.14: Lake Nasser - cropping patterns in October 2005 – May 2006

Crop	Area feddan
A. Field Crops:	
Wheat	323
Onion	28
Faba bean	28
Egyptian clover	50
Fenugreek	7
Lupin termes	13
Corn (Zea mays)	102
Sub-Total	**551**
B. Vegetables:	
Tomatoes	1,049
Eggplant	200
Sweet Pepper	248
Water melon	1,415
Cucumber	163
Squash	269
Cantaloupe	73
Sub-Total	**3,427**
C. Medicine & Aromatic plants	**16**
Total	3,984

Source: CRA Report, Egypt (2007), Aswan Agric. Directorate

The crop productivity of Lake Nasser shore farms is compared to that of Aswan Governorate in Table 5.15. This reveals that the yield of wheat, clover, pepper and cantaloupe are on the average less around Lake Nasser than the average yield for Aswan Governorate by 10, 25, 11 and 30% respectively, whilst Lake Nasser farms produce higher yields of corn, tomatoes, water melon and cucumber than Aswan Governorate.

Table 5.15: Average crop yields Lake Nasser farms and Aswan Governorate crop yield averages (2004/06)

Crop	Average Yield (ton/feddan)		Difference Ton/fed.	% decrease
	Aswan Governorate	Lake Nasser		
Wheat	1.5	1.35	0.15	10
Egyptian clover	20.0	15.0	5.00	25
Onion	4.0	4.0	0.00	0.0
Corn	1.35	1.5	(0.15)	(+11)
Faba bean	0.70	0.7	0.00	00
Tomatoes	12.00	18.0	(6.0)	(+50)
Pepper	4.5	4.0	0.5	11
Cantaloupe	4.3	3.0	1.3	30
Water melon	11.5	12.0	(0.5)	(4.3)
Cucumber	4.5	5.0	(0.5)	(11)

Source: CRA Report, Egypt (2007), Aswan Governorate Agriculture Directorate; HD Development Authority.

It may be noted in Table 5.13 that the total number of farmers currently engaged in cultivation around the lake and in its annual drawdown zone is about 1,000 persons.

Research is the key to sustainable agricultural development around the lake. To-date, research has pinpointed the following list of important constraints. Some are particularly with regard to cultivation of lakebed soils as the lake recedes from higher levels following the annual flood:

- Sandy soils that are excessively drained.
- Difficulty of levelling the surface layers; and therefore, slope cultivation is commonly used.
- Fluctuation of Lake water level during growing season.
- Absence of organic matter.
- Lack of macro-and micronutrients.
- Shallowness of topsoil.
- Presence of soluble or less soluble salts such as calcium carbonates and gypsum.
- Continual change in the surface layer as a result of wind movement.
- The presence of certain harmful elements such as boron and selenium.
- Salinity and alkalinity problems.
- Drainage problems.
- Poor research/extension linkages.
- Lack of certified seeds.

Economic problems are reported to include:

- Lack of sufficient investments in infrastructure facilities. This problem was further aggravated by inadequacy of monetary liquidity, prolonged procedures of lending.
- Inability of the official investments to create integrated settled communities in and around the lake to attract new settlers from the Nile Valley and Aswan - which are already overpopulated and parts of their croplands are lost to urban uses.
- Inaccessibility to credit by the new graduates and beneficiaries thus impeding their ability to fully use their lands.
- Marketing accessibility.

Nevertheless, plans exist for additional irrigation and associated settlement. Developments and development proposals relating to large-scale irrigation, Mubarak pumping station and the Sheik Zayed Canal are described in Section 5.4.4 (along with irrigation in Ethiopia and Sudan).

Livestock

The number of livestock around Lake Nasser margins (24,500) is extremely low. Sheep and goats make up some 88% of the total, with camels accounting for 11%.

Fisheries

The fisheries sector of Lake Nasser is under the control of the General Authority of High Dam Development (GAHDD). There are four major Fishermen Associations comprise about 5,000 fishermen.

The major fish families and species in Lake Nasser are listed in Table 5.16.

Table 5.16: Lake Nasser - Major Fish Families and Species

	Family	Species
1	Cichlidae	*Tilapia nilotica* *Tilapia galilaea* *Tilapia zilli* *Oreochromis aureus* *Sarotherodon galilaeus* *Oreochromis niloticus*
2	Centropomidae	*Lates niloticus*
3	Characinidae	*Alestes nurse* *Alestes baremose* *Alestes dentex* *Hydrocynus forskahlii* *Hydrocynus lineatus* *Hydrocynus brevis*
4	Cyprinidae	*Barbus bynni* *Labeo niloticus* *Labeo coubie* *Labeo horie*
5	Bagridae	*Bagrus bayad* *Bagrus docmac*
6	Clariidae	*Heterobranchus bidorsalis* *Clarias lazera*
7	Schilbeidae	*Eutrophius niloticus* *Schilbe mystus* *Schilbe uranoscopus*
8	Synodontidae	*Synodontis schall* *Synodontis serratus*
9	Mormyridae	*Mormyrus kannume* *Mormyrus caschive* *Mormyrus anguilloides* *Petrocephalus bane*

Source: CRA Report, Egypt (2007) from Rashid, 1995

Fish abundance and distribution in the lake is reported to vary among the different sectors of the reservoir and side-bays. Many factors play an important role in the fish population and density as the migration of certain types of fish is dependent on the arrival of the turbid flood water, the preference of riverine or semi-riverine conditions, reproduction habitats and spawning or food and feeding habits. Spawning of some cyprinids and characins species which live mainly in Lake Nubia (Sudan) is induced by the Nile's annual flood. The fishes move upstream beyond the Second Cataract where the reservoir is much shallower and narrower and the arrival of the flood water, with its increasing turbidity and velocity, probably triggers their spawning process (Rashid, 1995). (Sediment deposits near the Second Cataract are reported to have reached about 20 m depth by 1973 and 60 m by 2000).

The fish food items in Lake Nasser/Nubia are periphyton, phytoplankton and zooplankton, insects larvae (chironomids), gastropods, bivalves, juvenile fishes and fresh water shrimps.

The Lake was reported to be providing adequate supplies until 1981 when production started to plummet. Over the last two decades, fishermen have proceeded with their work despite the steady decrease in the quantity of fish they produce - from a peak of 34,000 tons in 1981 to 8,000 in 2000, since when reported catches have increased (Table 5.17).

Table 5.17: Lake Nasser Fish Production, 1966-2005

Year	Total (ton)	Year	Total (ton)
1966	751	1986	16,315
1967	1,415	1987	16,815
1968	2,662	1988	15,888
1969	4,670	1989	15,650
1970	5,676	1990	21,882
1971	6,819	1991	30,838
1972	8,343	1992	26,219
1973	10,587	1993	17,931
1974	12,255	1994	22,074
1975	14,635	1995	22,058
1976	15,791	1996	20,540
1977	18,471	1997	20,503
1978	22,725	1998	19,203
1979	27,021	1999	13,983
1980	30,216	2000	8,281
1981	34,206	2001	12,164
1982	28,667	2002	22,093
1983	31,282	2003	17,029
1984	24,534	2004	12,434
1985	26,450	2005	15,285

Source: CRA Report, Egypt (2007), from HDLDA - Fisheries Department

The most important species in the fish landings are cichlidae with *Tilapia nilotica* and *Tilapia galilaea* forming about 90 % of the total fish landings (Rashid, 1995). Cyprinids *Labeo nilotica* and *L. horie* rank second and together with *Barbus bynni* formed 6 %.

It has been shown that seasonality plays an important role in fish landing. The highest fish landings characterize the period March to April, which coincides with the peak spawning of Tilapia in the Lake.

Because of plummeting production figures, Law 324 was issued in 2000. It re-allocated fishing space, giving the fishermen's associations only 60%, with 40% handed over to six private sector companies - a move that generated unrest among fishermen, resulting in conflict between the associations and the governorate. The companies promised to increase production to over 40,000 tons per year by fishing at lower depths and developing breeding farms, thereby exploiting the full potential of the lake (Dena Rashed, 2005).

The Lake is characterized by the existence of many khors and lagoons on its banks. The number of the important khors is 85; 48 on the east bank and 37 on the west bank. Khors are considered suitable habitat for fish rearing due to slow water current and phytoplankton growing in them.

According to 1985 studies, there were 1,683 boats used in fishing in the lake with an average catch of about 10 tons per boat per year.

The fishing surface of the lake is divided into two fishing areas (zones). Fishing in shallow water khors around the shores, which represents about 20% of the lake surface. The formation of flood khors and lagoons on and around the lakeshores provides natural habitat for Nile Tilapia breeding. Tilapia tends not to migrate from these habitats, therefore restocking the lake with Tilapia fingerlings is one way to increase production and to introduce aquaculture to the lake. During year 2005, some 17 million Tilapia fingerlings were released in the lake from hatcheries at Sahra, Garf Hussein and Abu-Simbel.

Fishing in deep water represents 80% of the lake surface. Despite the presence of phytoplankton in deep water, very few fish live in deep water. This indicates the need to consider introducing fish species adapted to the deep-water zone.

A Japanese study has estimated the lake potential at 80,000 tons per year. The governorate of Aswan information states that 60,000 - 70,000 tons of fish are yearly smuggled out of the lake. To reach the potential of 80,000 tons, some infrastructure developments are essential. These include establishing three new fish hatcheries, three docks for boats, ice factories and a fish processing and canning factory.

Researchers identify a number of problems related to the low productivity of fisheries in Lake Nasser. These include:

- Fishermen use illegal fishing methods including nets with mesh smaller than the legal limit.
- Unlicensed boats.
- Smuggling of fish (up to 60,000 - 70,000 tons)
- Over-fishing: excessive and indiscriminate fishing occurs in the lake.

Issues to carry forward

It may be noted therefore, with regard to considering regulatory storage development in Ethiopia (to be considered later), that some 5,000 fishermen in fishermen's associations, using around 1,600/1,700 boats, and some private sector companies are engaged in Lake Nasser fisheries for their livelihoods; that fisheries development, along with irrigation development (with currently about 1,000 farmers cultivating land), is expected to become more important in future; and that the Nile's annual flood is considered to trigger spawning of some fish species in the Nubian parts of the lake.

It is further noted that after the major 1988 flood, which ended a major drought sequence, reservoir levels began to rise, with full storage levels again reached during the 1990s. The Toshka spillway played an important part in flood control and management during 1998 and 1999 high floods. In 1998, the total discharge passed through it was 12.4 billion m^3 and during the 1999 flood it passed about 16 billion m^3. It is an interesting feature that the years with markedly low fisheries production (about 8,000 tons and 12,000 tons in 2000 and 2001 respectively) followed these years with large spillway flows. This appears to beg the question, among others, of whether breeding and non-breeding fish in large numbers were attracted by currents and drawn into the Toshka spillway, causing a significant reduction in harvestable numbers, and presumably fishermen's incomes, in the following two years; and what might the fisheries situation have been with upstream storage development in Ethiopia reducing or avoiding these Toshka spillway flows and reducing the very high sediment loads.

5.4 IRRIGATION IN BLUE AND MAIN NILE SUB-BASINS

5.4.1 Overview of Existing and Potential Irrigation

The irrigation potential of the Eastern Nile sub-basin has been estimated at 9,390,000 ha of which 47% is in Egypt, 24% in Ethiopia and the remaining 29% is in Sudan. Out of the existing potential in each country Egypt has realized 66% and Sudan 70% while Ethiopia has implemented only 1.4 % of the potential. In terms of water use, Egypt has utilized over 70% of the Nile water while Sudan has utilized over 27%. Ethiopia has used 0.5% of the water resources of the Abbay basin. Details are given in Table 5.18.

Table 5.18 : Existing and Potential Irrigation Area of Eastern Nile Countries

No.	Country	Irrigated Area (ha)			% of Potential realized	Water Used for Irrigation	
		Country	Nile Basin	Potential		($10^6 m^3$)	%
1	Ethiopia	160,785	23,160	2,220,000	1.4	321	0.5
2	Egypt	3,245,700	3,078,000	4,420,000	66.1	42,690	70.2
3	Sudan	1,930,300	1,935,200	2,750,000	70.2	16,663	27.4
TOTAL		**5,336,785**	**5,036,360**	**9,390,000**		**59,674**	

Source: Karadobi multipurpose project pre-feasibility study - Initial Environmental Assessment, NORPLAN, May 2006.

5.4.2 Irrigation in Abbay basin

In the Abbay basin, small-scale irrigation schemes are the mandate of regional states while medium and large-scale schemes are the mandate of the federal government. In addition to the existing 23,000 ha, some 25,000 ha are currently under study for implementation and a further 80,000 ha have been assigned for feasibility study (Table 5.19).

Table 5.19: Proposed Irrigation schemes in Abbay basin

Abbay basin irrigation projects	Area ha
Fast-track Implementation	
Megech Pump Project	5,400
Ribb	14,600
Anger Dam Project	5,000
Sub-Total[1]	**25,000**
For feasibility Study	
Megech	16,660
Uper Beles	40,880
Anger Dam	12,000
Negesso	10,460
Sub-total	**80,000**
TOTAL	**105,000**

Source: Compiled from TAHAL study, 2006

5.4.3 Irrigation in Sudan

Irrigation crops in Sudan are very diverse. The main crops are sorghum, cotton, wheat, fruits and beans. Other crops include vegetables, fodder, groundnut and maize. In future, the aim is to convert existing basin irrigation to high intensity perennial irrigation, including potential irrigated areas, and to intensify existing pump schemes (Ministry of Irrigation and Water Resources, Sudan, 1979).

Account has been taken of all irrigation schemes in the White, Blue and Main Nile sub-basins in Sudan in the RAPSO modelling of the river system.

Table 5.20: Projected Irrigation Water Requirements in Sudan

Nile Tributary	Cultivated Area (1,000 Feddans)		Water Requirement (Mm^3)	
	2002	**2012**	**2002**	**2012**
The Blue Nile	2112	3186	9050	11481
The White Nile	480	1067	2050	4968
Atbara River	282	572	1270	2123
Main Nile	311	571	1300	1903
Reservoir Evap.			880	3170
Total	3185	5396	14450	23645
Other usage			1080	2500
Total			15530	26145

Source: Long-Term Agricultural Strategy (2002-2027)

[1] The net irrigation area is equivalent to 20,000 ha making the total 100,000 ha.

Consultations with Ministry of Irrigation and Water Resources in Khartoum first indicated an overall irrigation development capital cost of USD 1,000 per feddan along the Main Nile. This was understood to include the costs of planning, surveying, designing and implementing new pumped irrigation areas. Later, the Ministry provided a revised development cost of USD 4,000 per feddan where this includes annual running costs but the years of operation were not stated.

The Ministry also indicated that proposed irrigation schemes for implementation within the foreseeable future along the Main Nile cover 121,210 feddan. The schemes include Wad Hamid basin 17,000 feddan; Salwa basin 7,000 feddan; Salem 55,210 feddan; Letti 7,000 feddan; Khor Argo 30,000 feddan; and Khor Hadnab 5,000 feddan. It is understood that these areas are currently productive following recession of the annual flood. When converted to irrigation, they will have potential for growing two crops each year.

5.4.4 Irrigation in Egypt

Wide-ranging consultations with former (but still very active) directors of Ministry of Water Resources and Irrigation were held in Cairo in January 2007 following the ENTRO workshop in Cairo. Most issues related to Egyptian experience of irrigation in the post High Aswan Dam era but they also related to matters such as sediment transport, river training and irrigation projects listed on the Ministry's website. The major points are summarised below.

Water use efficiency

The former directors indicated that consideration continues to be given to economising on irrigation water use and improving efficiency. For example, rice and wheat irrigation are cited as providing relatively low yields per cubic metre of applied irrigation water compared to other crops. However, in some areas, other factors are important; for example, rice will continue to be needed on the edge of the Nile delta where it acts as a buffer against the Mediterranean Sea.

River Training

Since operations of High Aswan Dam began, sediment transport was drastically reduced in regulated flows downstream. Egyptian experience of this has been that river training has become essential. With reduced sediment loads because of siltation in Mandaya/Border reservoirs, adjustments in Nile river morphology must be expected. It was noted that Egypt now has a Section for Protection of the Nile in the Ministry which is dealing with river training.

Increasing Sediment Loads at High Aswan Dam

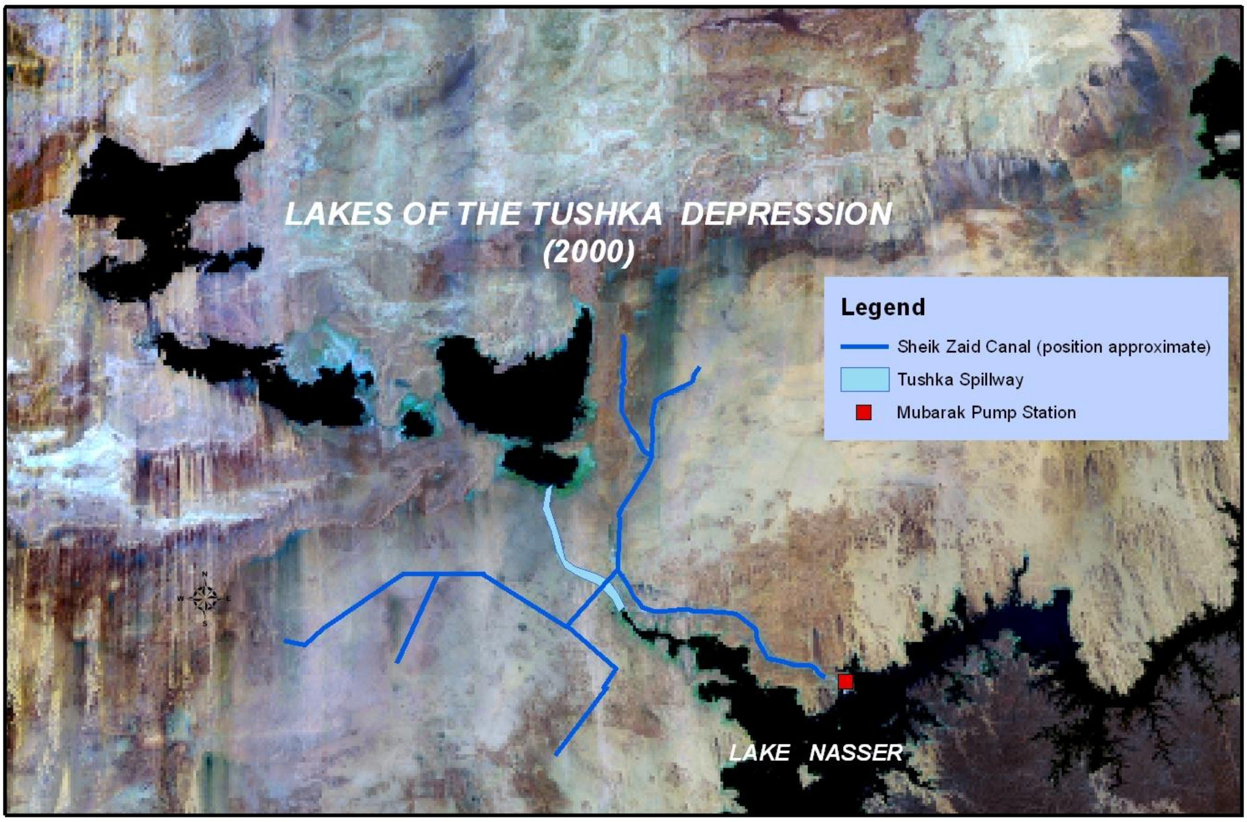
It was noted that sediment loads have increased at High Aswan Dam, especially it was reported in the last 10-15 years. (It may be noted that this comment therefore refers to the post-1992 situation when the mean rate for the 5-year study period between 1987 and 1992 was estimated at 186 million tons per year. See Section 5.3.6). This comment is based on more recent data which was not available to examine. It again supports our concerns expressed about the inadequacy of sediment transport data at Kessie, Border and El Deim in Chapter 4, believing that sediment transport rates of the Abbay are currently much higher than previously estimated.

Mubarak Pumping Station and Sheikh Zayed Canal

It was explained that although the Ministry's website provides details of the Mubarak Pumping Station, it was confirmed that it is constructed but is so far unused. There is currently no irrigation directly from Lake Nasser. When this occurs, water will be taken from Egypt's allocation with reductions occurring elsewhere. A Sudanese hydrometrist is stationed and measures flows at the Gaafra river gauging station below High Aswan Dam. When Mubarak pumping begins, Sudan will post another member of staff for recording abstractions at Mubarak.

Although the Ministry's website refers to Toshka township in connection with the irrigation project, it was pointed out that this has nothing to do with Toshka spillway which is at 178 masl and upstream of Mubarak pumping station. The name is common but they are totally separate projects (Figure 5.28).

EGYPT
LAKE NASSER
THE TUSHKA SPILLWAY AND LAND RECLAIMATION PROJECT



Source: CRA Egypt Report (2007)

Figure 5.28: The Tushka Depression, Spillway, Sheik Zaid Canal and Ephemeral Lakes after the 1999 Spill (Landsat TM Image 2000)

Resettlement is very costly. All the required social services are costly. There is a problem in getting farmers to work in the Toshka area. The new town does not yet exist. Fly camps may be there for construction purposes. As the Main Canal cannot be operated for irrigating tiny areas currently, groundwater is being used for the very small plots.

For completeness, details of the Mubarak Pumping Station and Sheikh Zayed Canal taken from the Ministry's website are given below. These vast projects may be operating before Mandaya or Border projects become operational.

The main pumping station will draw water from Lake Nasser and release it into the Sheikh Zayed Canal through a discharge basin. The 21 pumping units within the station can lift 5,000 million m^3/year. (This is equivalent to a river's mean annual flow of 159 m^3/s). These units can be increased by another three. Aswan's power station will supply the 250 megawatts of electricity required for operation. (It may be noted therefore that this future power requirement is in the south of Egypt and is equivalent to one eighth of Mandaya's installed capacity).

A 50 m deep intake channel, the deepest inland channel ever constructed, will feed water to the pumping station. Two of the largest marine excavators in the world were chosen to accomplish this mammoth task. A consortium of three companies was selected to conduct the USD 440 million project.

The differences between the elevation of the canal (201 masl) and the water levels of Lake Nasser, which vary between 147 masl and 182 masl, are 54 m and 19 m. The maximum static lift is 52.5 m.

Paramount to the creative design of the station was that the edifice would reflect Egypt's rich cultural heritage. The final design was chosen because of its dynamic use of Pharaonic style architecture. Innovative policies have been implemented to protect the environment from noise and oil pollution that might typically accompany the operation of a pumping station of this size.

In Phase I of the Toshka project, water will be pumped from approximately 8 km north of Khor Toshka (an inlet of Lake Nasser) and released through a concrete-lined canal to feed the selected plots of land. The depth of the main canal is 7m; its widths at the bottom and at the surface are 30 m and 58 m respectively. The main canal's length is 72 km; it splits into two branches, with each branch irrigating 120,000 acres. Other sub-branches will deliver irrigation water, making a total of 540,000 acres. The total cost of the Sheikh Zayed Canal and its branches is approximately USD 1.2 billion.

The Sheikh Zayed Canal has been named after Sheikh Zayed Bin Sultan El Nahayan, president of the United Arab Emirates. This recognition is for his donation to the project through the Abu Dhabi Development Fund.

Government subsidized accommodations, services, and infrastructure at Toshka township will provide modern conveniences for workers and easy access to their jobs. New kindergarten and preparatory schools, clinics, a police station, cinemas, and sports and social clubs are expected to be provided.

In Phase 2, it is proposed that the canal will continue north to Darb El Arbe'ien, then to the town of Paris, the capital of the New Valley Governorate (Figure 5.23). An additional 400,000 acres will be cultivated. The Sheikh Zayed Canal is designed to convey up to 25 million m^3/day (290 m^3/s) from Lake Nasser, which will accommodate Phase 2.

The Ministry's website draws attention to the project's necessity, noting that the South Egypt Development Project has been a great dream of the Egyptian people for a long time, the dream of getting out of the narrow strip of the overpopulated Nile valley to the large expanse of land in south Egypt.

The project's new area of agricultural land may reach one million feddans. The project expects to establish agricultural and industrial communities, structural incentives to attract the work force and a network of main roads and airports. Promotion of tourism is also proposed, the region being rich in ancient monuments.

The West Delta Water Conservation and Irrigation Rehabilitation Project

Another project described on the Ministry's website will require Nile water resources, again from within Egypt's allocation. The Ministry of Water Resources is offering a unique opportunity for Public-Private Partnership in irrigation. It comes as part of the continuing effort by the ministry to improve water management, increase water productivity, and encourage water conservation and sustainable development. The West Delta Water Conservation and Irrigation Rehabilitation Project is part of a much larger plan to improve and extend irrigation to new lands along the western fringes of the Nile Delta.

The project will provide surface water to the southern part of the west delta where agriculture is flourishing to produce high value crops for the domestic and foreign markets. Huge investments by farmers and private sector were made over the past two decades to introduce modern agriculture and agri-business in the area.

As demands are fast growing for surface water to replace declining groundwater that is currently the sole source for irrigation, a private operator will be selected on competitive basis to design, build and operate a surface irrigation system. The proposed public-private partnership provides incentives and includes measures that makes the project an opportunity for success.

5.5 HYDROPOWER GENERATION ON BLUE AND MAIN NILE

The existing multi-purpose reservoirs on the Nile river system in Sudan, shown in Table 5.21, are used primarily to store water for irrigation purposes. Work to raise the Roseires Dam, though started, has not progressed as had been planned.

Table 5.21 : Characteristics of Existing Reservoirs in Sudan

Reservoir	River	Dam Completed	Live Storage BCM	Full Supply Level (masl)	Minimum Operating Level (masl)	Installed capacity (MW)
Jebel Aulia	White Nile	1937	3.89	377.4	372.5	28.8
Roseires	Blue Nile	1966	2.12	481	467.6	280
Sennar	Blue Nile	1925	0.48	421.7	417.2	15
Khashm el Girba	Atbara	1964	0.617	474	463.5	12

Source: RAPSO model, Pre-feasibility engineering report (2007)

In order to eliminate the current electricity deficit, the Government of Sudan is currently constructing the 60 m high Merowe Dam some 400 km north of Khartoum at the Fourth Cataract. The reservoir will submerge the fourth cataract of the Nile and form a 200 km long artificial lake. With a surface area of 800 km^2, the lake will inundate 55 km^2 of irrigated land and 11 km^2 of farmland used for flood recession agriculture. The project includes irrigation and resettlement components. The dam will have an installed capacity of 1,250 MW, three times Sudan's current capacity. The reservoir will have an active storage capacity of 8,300 Mm^3. Fitted with deep sluices, these could be used to operate the dam at a relatively low level during the period of highest sediment concentration. Whilst reducing power output, this would reduce sedimentation within the dam.

The major problem at all dams except Jebel Aulia is sedimentation. Sedimentation reduces live storage capacity, thereby reducing firm yield, power output and irrigation supplies. The methods of operation to permit the bulk of the heavy sediment loads of the annual flood to pass through these reservoirs by keeping sediment sluices and/or spillway gates open, when they would otherwise be closed, has been modelled in the RAPSO model. This is described in the Mandaya and Border pre-feasibility engineering reports (2007).

5.6 FLOODING CHARACTERISTICS OF BLUE NILE AND MAIN NILE

5.6.1 Introduction

The annual flood of the Nile is of inestimable importance to riverside settlements, agriculture and all activities in the desert. Although flow is perennial and water is always physically available in the river channel in all seasons, it is the annual rise and fall of water level which is critical for delivering water to the riverine strip of alluvial soils for cultivation, grazing, date palms, citrus, other tree crops and shade trees, and for recharging groundwater resources. However, the highest floods cause major public health problems, damage to properties in settlements and to flood defence dykes, irrigation schemes and equipment[2].

Because any large reservoir developments on the Abbay/Blue Nile will cause adjustments to the Nile flood regime and many people's activities dependent on it, Sudanese people living in the desert are stakeholders and have an abiding interest in what upstream storage(s) and river regulation may mean for them.

In contrast, the White Nile's contribution to the Main Nile at Khartoum is generally "steady" throughout the year having been comprehensively naturally regulated by Lake Victoria and other lakes and swamps (and notwithstanding some relatively minor modifications to its regime by upstream developments). The White Nile's steady contribution to the Main Nile is nevertheless vital in the north because it can be thought of as providing the baseflow on which rides the Blue Nile's annual flood. (The Blue Nile's annual flood includes the Rahad and Dinder annual floods). The Atbara's annual flood joins the Main Nile between Shendi and Merowe and its peak may or may not coincide with the peak of the Blue Nile's annual flood.

5.6.2 Flood Warning System

The Ministry of Irrigation and Water Resources has established a flood warning system along the Nile. Control Levels (CLs) are established and divided into four categories: "Normal", "Alert", "Critical" and "Flooding". These are determined according to the morphology of the river, riverbank conditions and topography. As a result, the CLs have both flooding and agricultural significance as follows:

- "Normal" - the flood is considered as "Normal" if the flow during the flood is confined within the banks of the river;
- "Alert" – the flood is determined as "Alert" if the flow tops over the banks of the river and floods part of the farm lands and agricultural areas adjacent to the river;
- "Critical" – the flood is considered as "Critical" if all the flood plain and cultivated areas are flooded;
- "Flooding" – the flood is considered as "Flooding" if permanent residential areas near the river are affected.

Table 5.22 shows the Control Levels adopted along the Blue and the Main Nile, using the colour coding adopted by the Ministry.

[2] Following presentation of the draft IEA reports on Mandaya and Border at the workshop in Cairo in July 2007, the Consultant's attention was drawn to a report on an appraisal of flood damages along the Blue and Main Nile prepared for the World Bank (Michael Cawood & Associates, 2005). Extracts from this are presented in Appendix 5.2 where the cost of mitigating damages along the Blue and Main Nile for a 100-year flood is estimated at USD 527 million, and the average annual damage is estimated at USD 52 million.

Table 5.22 : Flood control levels along Blue and Main Nile

Control Level	El Deim	Wad Medani	Khartoum	Shendi	Atbara	Dongola
Normal	<10.8	<18.4	<15.0	<16.1	<14.18	<13.47
Alert	10.8 – 11.8	18.4 – 19.4	15.0 –16.0	16.1 – 17.1	14.18 – 15.18	13.47 – 14.72
Critical	11.8 – 12.3	19.4 – 19.9	16.0 – 16.5	17.1 – 17.6	15.18 – 15.75	14.72 – 15.22
Flooding	>12.3	>19.9	>16.5	>17.6	>15.75	>15.22

Source: Ministry of Irrigation and Water Resources, Khartoum

In all cases except Dongola, the Alert level range is 1.0 m. This means that the water levels are up to 1.0 m higher than the bankfull discharge and benefit part of the farmlands and agricultural areas adjacent to the river. This may be interpreted as many agricultural areas benefiting from water and silt deposits but some farming communities will be disappointed that floodwater and silt does not reach them. At Dongola, this range is slightly greater at 1.3 m.

In all cases except Atbara, the Critical level range is 0.5 m. This means that the water levels are up to 0.5 m higher than the Alert level and benefit all farm lands in the flood plain. In this case, all agricultural areas benefit from water and silt deposits and, generally speaking, no farming communities will be disappointed that flood water and silt does not reach them. At Atbara, this range is slightly greater at 0.57 m.

At "Flooding" levels, permanent residential areas near the river are affected. These are the levels at which damage to property is caused, and when flood protection dykes may be overtopped or breached incurring additional maintenance costs compared to less severe flood years. The flood duration is longest in this case, delaying the time of planting and beginning of plant growth on the flood's recession.

5.6.3 Interpretation of Flood Experience, Khartoum to Dongola

Table 5.23 shows the percentage frequency of occurrence of the flood warning different categories at stations along the Blue and the Main Nile for the 42-year period 1965 - 2006. Concentrating on the stations at Khartoum, Shendi and Dongola, the table reveals close agreement at these stations.

Table 5.23 : Percentage frequency of occurrence of control levels 1965-2006

Control Level	El Deim	Wad Medani	Khartoum	Shendi	Atbara[1]	Dongola
Normal	0	22	7	7		7
Alert	14	46	43	45		45
Critical	31	20	26	26		29
Flooding	55	12	24	22		19
All	100	100	100	100		100

Source: Ministry of Irrigation and Water Resources, Khartoum

Notes: In data supplied, 42 years of record at all stations, but at Wad Medani 1974 is not included.
[1]At Atbara 1975, 1976, 1980 and 1984 are not included, and two CLs are given to 1972 (Normal and Critical) and 1978 (Normal and Critical). Data for Atbara is therefore not strictly comparable.

From farming and livelihoods points of view along the Main Nile from Khartoum to Shendi to Dongola (and by inference downstream of Dongola to Lake Nubia), the various situations may be summarised as follows:

"Normal" flood years present crisis conditions (food shortage) because the river does not flow out of its banks, unless an area enjoys pumping facilities for irrigation. 1972 and 1984 are common years at all station (Table 5.24);

Table 5.24 : Normal Flood years – when Alert level not reached

El Deim	Wad Medani	Khartoum	Shendi	Dongola
1972	**1972**	**1972**	**1972**	**1972**
1982	1977	**1984**	**1984**	1982
1984	1979	1986	1986	**1984**
1986	1981			
1987	1982			
1999	**1984**			
	1986			
	1987			
	2002			

Source: Ministry of Irrigation and Water Resources, Khartoum

Notes. Emboldened year 1972 and 1984 are common to all stations
Atbara excluded because of missing years and double accounting.

"Alert" years, occurring in a little under half of all years, are good for many but not for all (for whom there may be food shortage);

"Critical" years, occurring in about one year in four, are good for all – all the flood plain is flooded and receiving a dressing of silt as a fertilizer; (the word "critical" here refers to potential imminent flooding of properties and breaching of dykes in the flood warning sense of critical levels; for future agricultural production on the flood recession and for future water supplies from recharged groundwater and mataras, the situation is not critical but welcome and perhaps almost "ideal");

"Flooding" years are a mixed blessing – they support recession agriculture in the following months, fully recharging groundwater and mataras adjacent to the floodplain and encouraging spawning and fish recruitment, but cause major public health problems, delay cultivation, seriously spoil communications and cause damage to properties, equipment and flood protection dykes – all incurring heavy costs.

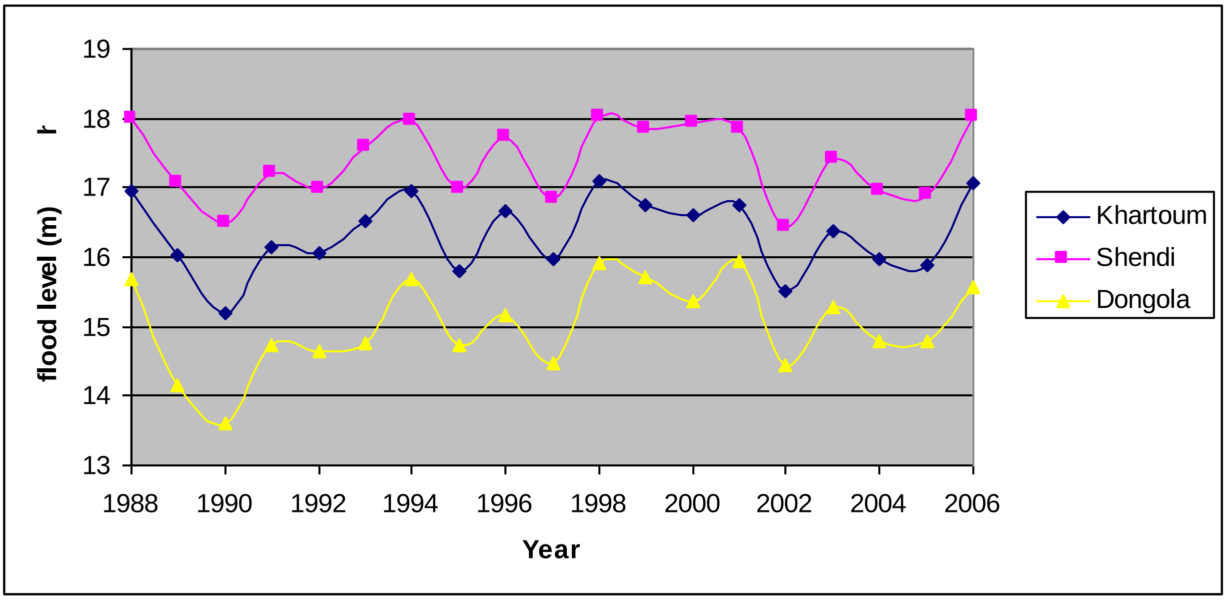
The chronological sequence of flood warnings in the 19-year period 1988 – 2006 is shown Table 5.25. The close agreement between stations for "Flooding" may be noted.

Table 5.25 : Flood warnings in the 19-year period 1988 – 2006

Year	Flood level (m) & warning colour code		
	Khartoum	Shendi	Dongola
1988	16.94	18.00	15.69
1989	16.04	17.07	14.15
1990	15.20	16.50	13.60
1991	16.14	17.22	14.72
1992	16.05	16.98	14.64
1993	16.53	17.59	14.76
1994	16.94	17.96	15.69
1995	15.81	16.97	14.74
1996	16.67	17.72	15.17
1997	15.97	16.85	14.48
1998	17.09	18.01	15.91
1999	16.75	17.84	15.72
2000	16.60	17.93	15.37
2001	16.74	17.85	15.93
2002	15.52	16.42	14.44
2003	16.38	17.40	15.29
2004	15.98	16.96	14.80
2005	15.88	16.89	14.80
2006	17.08	18.02	15.57

Source: Ministry of Irrigation and Water Resources, Khartoum

Annual maximum instantaneous levels, given in Table 5.25 above, are plotted in Figure 5.29. It is seen that there is close agreement in the pattern of flooding at stations from year to year.



Source: Ministry of Irrigation and Water Resources, Khartoum

Figure 5.29: Annual maximum instantaneous flood levels (1988 – 2006)

5.6.4 Agricultural and other land dependent on the Annual Flood

One of the many questions concerning reservoir storage development in Ethiopia relates to the Nile's annual flood regime. "What area of productive land along the Nile in Sudan is dependent on the flood regime?" There is no known existing documentation of this.

In Egypt, the question does not now arise because High Aswan Dam provides comprehensive control of the Nile's annual flood. Cultivated areas in the Nile valley and Nile delta which were, for millennia, formerly dependent on the annual flood are now supplied throughout the year by releases from High Aswan Dam. These regulated releases supply not only irrigation schemes in place of and in addition to former flood recession agricultural areas but domestic, public and industrial water supplies.

In order to obtain some understanding of the situation in Sudan to assist this study, the Remote Sensing Authority in Khartoum has carried out analysis of satellite images along the Blue and Main Nile to determine areas of agricultural activities adjacent to the river. Details are given in Appendix 5.1. The agricultural areas so derived are the only known available data (Table 5.26).

Table 5.26 : Agricultural areas along the Nile supported by Annual Flood

Nile reaches Ethiopian border to Lake Nubia	Agricultural Area ha	Agricultural Area feddan
Ethiopia border to Roseires dam	300	700
Roseires dam to Khartoum	83,800	200,000
Blue Nile	**84,100**	**200,700**
Khartoum to Merowe dam	169,100	402,000
Merowe dam to Lake Nubia (Wadi Halfa)	110,900	264,000
Main Nile	**280,000**	**666,000**
Total	**364,100**	**866,700**

Source: This study. Remote Sensing Authority, Khartoum. Appendix 5.1

5.6.5 Pumped water supplies for irrigation to replace the Annual Flood

If one or other upstream storages in Ethiopia regulate Blue Nile flows so effectively that regulated flows downstream in the annual flood season do not reach the “Alert” or “Critical” levels regularly, the mitigation measure to maintain agricultural production and livelihoods for communities alongside the Blue and Main Nile river would be to introduce pumped irrigation schemes. Some pumped irrigation schemes already exist in these areas and some are already planned for implementation (e.g. 121,000 feddan on Main Nile referred to earlier). Once installed, irrigation for two crops could be introduced instead of the one crop from recession agriculture.

Artificial fertilizer use would be expected to increase costs of production owing to siltation of upstream reservoirs causing reduced sediment transport downstream. In addition to capital costs for development, annual scheme maintenance costs would be incurred, including energy costs for farmers’ pumps and larger pumping stations. Other costs would include periodic riverbank stabilisation, river training or other pumping station protection works, anticipating changes in river channel morphology.

In order to assess water requirements for cropping these areas, annual water requirements for Nile “irrigation zones” in Sudan are adopted (FAO, 1997).

Table 5.27 : Irrigation water requirements to mitigate loss of Annual Flood

Nile reaches Ethiopian border to Lake Nubia	Agricultural Area		Annual gross water requirements	
	ha	feddan	FAO (1997) mm	Mm^3
Ethiopia border to Roseires dam	300	700	1500	-
Roseires dam to Khartoum	83,800	200,000	1500	1,260
Blue Nile	**84,100**	**200,700**	**1500**	**1,260**
Khartoum to Merowe dam	169,100	402,000	1750	2,960
Merowe dam to Lake Nubia (Wadi Halfa)	110,900	264,000	1750	1,940
Main Nile	**280,000**	**666,000**	**1750**	**4,900**
Total	**364,100**	**866,700**		**6,160**

Thus, to "replace" the annual flood by diverting/pumping regulated Nile water to areas (derived from remote sensing analysis) which would otherwise be supplied by flooding in "Alert" and/or "Critical" flood years, as if they were converted and developed as irrigation schemes, would require a supply in the order of 6, 160 million m^3 for two season cropping. This is equivalent to a continuous abstraction of approximately 195 m^3/s.

A number of points may be emphasised as follows:

- The Remote Sensing Authority's total agricultural area (866,700 feddan) includes cropped areas resulting from annual flooding and from pumped irrigation, including herbaceous crops, date palms and other tree crops. Areas were identified and mapped according to colour and pattern. They were easily distinguished from other categories such as water bodies and settlements. They were distinguished from rangeland/desert due to the fact that the images were acquired for the dry season (November/December 2001) when most of the grasses were dried up. Also, the pattern of agricultural farms is recognised clearly. Irrigated areas within the recession agriculture areas are included. Irrigated areas which were not adjacent to the river and outside of the flooding areas, e.g. Gezira, were purposely excluded.

- Thus, it is considered that the 200,700 feddan on the Blue Nile include none, or very little, of the 3,186,000 feddan irrigated in the RAPSO model.

- However, on the Main Nile, a large proportion of the 571,000 feddan irrigated in the RAPSO model from year 2012 may be included in the 666,000 feddan determined as agricultural by the Remote Sensing Authority. In other words, some of the water abstraction, 4,900 Mm^3/year, to replace the annual flood as mitigation on the Main Nile and to irrigate in the summer season, is already included in the quantities adopted for existing and proposed irrigation schemes for year 2012. It is not currently possible to determine how much. From this point of view, the estimated water abstraction of 4,900 Mm^3/year, to replace the annual flood as mitigation on the Main Nile and to irrigate in the summer season, will be overestimated.

- Also, it is reported that Merowe reservoir will inundate some 13,100 feddan (5,500 ha) of irrigated land and some 2,600 feddan (1,100 ha) of farmland when impoundment takes place. These areas will therefore be lost to cultivation and water requirements for these should be subtracted from the estimated water duties.

- The adopted FAO annual gross irrigation water duties are for a mixture of crops of generally short rooting depths and are here adopted as generally representing the water duties of horticultural and cereal crops. They do not therefore specifically provide for maintaining evapo-transpiration rates of grasses, herbs, date palm trees, citrus, neem shade trees or other trees which currently benefit from the Nile's annual flood. They do not specifically provide for recharging groundwater and the very important mataras which occur on both sides of the Main Nile's alluvial strip and which are so important for domestic water supplies and small irrigation schemes distant from the river. Thus, the water requirements for the Main Nile (overestimated because of some double accounting with the RAPSO model abstractions and because of Merowe's future impoundment) may be retained as a proximate value for current purposes.

- Whilst no irrigation scheme can provide the "generous" and "free" distribution of water of which the Nile's annual flood is capable, it is also true that the Nile has failed to produce floods above the "Normal" flood level (above bankfull discharge) in years like 1913, 1972, 1984 and 1986, and has caused great problems for public health and damage to cultivation, communications, properties, equipment and flood protection dykes – all incurring heavy costs – in years like 1988, 1994, 1998 to 2001 and 2006.

- These cautionary points emphasise that much greater study will be required of these matters in future.

It remains to be seen how the Mandaya hydropower project in Ethiopia may affect the magnitude and frequency of annual flood levels of the Blue Nile and Main Nile. This is presented in Chapter 7.

5.7 IDENTIFIED MAJOR ENVIRONMENTAL PROBLEMS

The CRA Report for Sudan (2006), referred to in Section 5.1 and subsequently throughout this chapter, summarises six identified major environmental problems. These directly or indirectly affect the water resources and water quality of the Blue and Main Nile and are background and on-going issues as we consider the impacts of the Mandaya project on the Blue and Main Nile in Chapter 7.

5.7.1 Sedimentation

Heavy sedimentation is reducing the storage capacity of the Roseires, Sennar and Kashm El Girba Dams and the irrigation and drainage canals of the irrigation schemes. Other impacts include increased costs of water purification, damage to pumps, aggradation of the riverbed causing accelerated meandering and riverbank erosion.

To this list we may add heavy siltation of Lakes Nasser and Nubia also, and Merowe in the near future.

5.7.2 Natural Resource Competition, Conflict and Rangeland Degradation

Under increasing population pressure and massive expansion of the large-scale mechanized farms there is increasing competition and conflict between natural resource managers: shifting cultivators, pastoralists/agro-pastoralists and mechanized farm owners. The loss of rangelands to mechanized farms has resulted in severe detrimental impacts on pastoralist livelihoods and livelihood strategies.

5.7.3 Soil Degradation

All forms of soil degradation are prevalent. Soil nutrient mining is occurring on the large mechanized farms because of continuous cultivation and the lack of fallowing. Salinization is occurring on a number of the irrigation schemes with poor drainage. Soil erosion occurs on areas with steeper slopes. Gullying is very common along the Atbara and Dinder rivers.

5.7.4 Water pollution

Some 600 agro-chemicals, many of which are hazardous to humans and livestock, are used on irrigated farms and much of the residue is washed into drains and eventually to the Blue Nile.

5.7.5 Underlying Poverty

Available evidence suggests that about 71-80 % of the population in the north is living below the poverty line. The majority of the poor live in the traditional rainfed farming areas. Distribution of benefits from agricultural growth during the last decade has favoured those with access to capital and land. Traditional agriculture shares 56% of agricultural GDP and 70% of the population; mechanized farming contributes 7% of agricultural GDP but only has 0.7% of the population. Irrigated agriculture contributes 22% of agricultural GDP and only has 12% of the population.

5.7.6 Pressures of Protected Areas

The Dinder National Park is under increasing pressure from the surrounding population with the demand for grazing, fuel wood and timber and more recently from the impacts of oil exploration.

6. CONSTRUCTION IMPACTS, IMPOUNDMENT AND MITIGATION MEASURES

This chapter considers the impacts of construction activities until the time when first filling of Mandaya reservoir occurs. Most project impacts are therefore already observed or occurring by the end of this period.

Section 6.1 covers the principal engineering construction impacts over a period of ten years and CO_2 emissions associated with the project's construction and operation.

Section 6.2 introduces the physical aspects of river diversion and then full reservoir impoundment.

Sections 6.3, 6.4 and 6.5 consider principal impacts on the physical, biological and socio-economic environment in the Mandaya region and mitigations for these – the direct impact zone.

Section 6.6 considers construction and impoundment impacts and mitigations in the downstream area in Ethiopia, and in Sudan and Egypt – the secondary impact zone.

The principal impacts and mitigation measures of the project are consolidated in a draft environmental management plan in Chapter 9.

6.1 CONTRUCTION ACTIVITIES AND MITIGATION MEASURES DURING PROJECT CONSTRUCTION

6.1.1 Access Roads – Impacts and Mitigation

The road network and its condition are poor in the dam site project area. Some roads will be upgraded and new roads will be constructed for the project. Alignments through sensitive ecological habitat, productive agricultural land and in locations where there are settlements and potential natural hazards (steep slopes, unstable soils and places where runoff and drainage are problematical) should be avoided where practicable. The major impacts and their mitigation associated with construction of roads by the contractor are summarized in Table 6.1. These generally also apply to access roads for transmission line construction.

6.1.2 Dam site and Quarries- Impacts and Mitigation

Excavated rock and dumped material may lead to unacceptable terrestrial, aquatic and socio-economic impacts if disposal is not carefully planned. Some spoil may be dumped in the reservoir inundation area where its visual and ecological impact will be later minimized. Other spoil will have to be integrated in to the landscape so as to form acceptable conditions with minimum impacts.

Quarries and borrow pits may be hazardous to people and livestock. Furthermore, some may be developed in materials which may contribute to enhanced erosion of sensitive landscapes. The exact location and extent of these quarry sites will be determined during Site Investigations of the feasibility study. The project contractor should prepare detailed site environmental management and monitoring plans in accordance with conditions stipulated in the project's environmental management plan (Chapter 9). These should address all matters relevant to environmental protection and minimization of impacts due to excavations, quarry development and other activities, including those of the workforce (Table 6.1). These generally also apply to transmission line construction.

Table 6.1 : Principal Impacts and Mitigation Measures during Construction Activities

Impacts during construction by contractor's works/workforce	Proposed mitigation measures - examples
Erosion and sediment – all sites	• Preserve top soil stripped from road edges and construction sites for re-use • Discourage grazing in disturbed areas until regeneration has taken place and new growth is firmly established • Erodible surfaces should be cut only during dry weather where practicable and re-planted as soon as possible
Spoil disposal – all sites	• Minimise numbers of spoil heaps; stabilize and re-vegetate them; consider dumping in the reservoir inundation area where practicable
Quarry development	• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely
Water quality	• Provide adequate sediment settling facilities for particulate matter in drainage from all works sites.
Chemical waste/spillage	• Ensure toxic compounds are not located near rivers and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly
Hazardous materials	• Provide safe systems for hazardous waste disposal
Dust and emissions	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly
Noise and visual disturbance	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas

Impacts during construction by contractor's works/workforce	Proposed mitigation measures - examples
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified • Avoid settlements and agricultural areas wherever practicable – all works areas
Landscaping and vegetation	• Minimize vegetation clearing for project infrastructure works • Remove potential "eyesores" of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing points
Vegetation clearing	• Remove woody material from reservoir area according to recommendations
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities
Coffer dam and reservoir impoundment	• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures • Liase with RAP officers
Environmental training for construction workers	• Provide training on environmental protection measures for flora and fauna
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials
Construction work camps	• Provide appropriate facilities for accommodation of workforce
Project staff health	• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health education for workforce, including education on STDs and HIV/AIDS

6.1.3 CO_2 Emissions during Construction and Operation

The Mandaya hydropower project offers potential for generating low priced and reliable energy to support regional economic growth. In the following sections the CO_2 emissions resulting from the project's construction activities and the decomposition of biomass in the project reservoir are quantified and compared with the potential CO_2 emissions from generating the same electrical energy through burning fossil fuels. Further details are given in Appendix 6.1. Impacts on other greenhouse gases, such as methane, should be considered during feasibility studies when better information becomes available about biomass quantities and decomposition in the reservoir.

CO_2 associated with the construction of the Mandaya hydropower project

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 172,000 tons. The burning of 172,000 tons diesel fuel will result in a CO_2 emission of about 557,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix as described below (coal/gas = 50/50 per cent) then some 222,000 tons of coal and 146,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 1,000,000 tons.

The total emission of CO_2 associated with the construction of the Mandaya hydropower project will thus be approximately 1,560,000 tons.

CO_2 associated with decomposition of biomass in Mandaya reservoir

Decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 2,600,000 tons, assuming that 50% of the woodland was used cut and as fuelwood.

CO_2 associated with emissions from equivalent thermal power plants

The annual average energy to be generated by the Mandaya hydropower project would amount to 12,119 GWh/yr. If the same quantity of energy was to be generated by a thermal mix consisting of 50 per cent coal-fired and 50 per cent gas-fired combined cycle power plants, some 8.5 million tons of CO_2 would be discharged to the atmosphere annually. It is noted that the CO_2 emission of 8.5 million tons annually is related purely to the fuel consumption (equal proportions of coal and gas) and does not include the CO_2 emission related to the construction of the thermal power plants. Over a period of 50 years, the assumed commercial life of Mandaya, this annual CO_2 emission would result in a total of 424 million tons of CO_2.

Consequently the generation of hydro-electric energy at Mandaya will result in CO_2 emissions 100 times less than if the same energy were generated by burning fossil fuels.

6.2 HYDROLOGICAL IMPACTS ON SITE DURING CONSTRUCTION

6.2.1 River Diversion

Abbay flows will occur normally in the river channel in the Mandaya reservoir basin during the construction period before first filling, except at the dam site and some distance upstream where water levels will be raised by up to 10 to 20 m (depending on flood flows received) when the upstream cofferdam for river diversion becomes operational. These cofferdam impacts may be expected approximately two years after construction activities begin. A first cofferdam, then a second cofferdam to facilitate river diversion will cause the river levels to rise in the flood season. In dry seasons, flows will be lower, passing through the diversion. Eventually, the RCC dam, progressively being raised, will be higher than earlier cofferdam sill levels and will itself cause upstream levels to be raised in the flood season; levels will fall back to low levels in the following dry seasons. The flooded area upstream will vary according to the magnitude of flows received and the stage of construction. Typically, the upstream pool level will not exceed 650 masl (Table 6.2). The area flooded will reach the Abbay/Didessa confluence and extend upstream in both valleys.

Table 6.2 : Mandaya Reservoir – Levels, Surface Area and Storage Volumes

Reservoir Level Characteristic	Level masl	Surface Area km^2	Volume $m^3 \times 10^9$
Full Supply Level (FSL)	800	736	49.2
Minimum Operating Level (MOL)	760	500	24.6
Difference between FSL and MOL	40	236	24.6
Pool level during construction, progressively rising, in flood season only, to about 650 masl (Upstream cofferdam sill level 640 masl + say 10m)	650	44	0.7

6.2.2 First Filling

When dam construction is nearly completed and the diversion closed, reservoir impoundment will raise water levels until eventually the reservoir attains full capacity. The filling period may take several wet seasons depending on the flows received and the downstream release pattern adopted to meet demands in Sudan and Egypt. First filling may be expected to commence in the 7th or 8th year of the 10-year construction program.

It may be noted that the reservoir storage capacity at Minimum Operating Level (24.6 billion m^3) is half of the gross storage capacity of the reservoir (49.2 billion m^3) and about 75% of one year's average flow (32 billion m^3). First filling requires reservoir levels to attain MOL in order to test and commission each turbine (8 No.). Whilst detailed studies of first filling have not been carried out, it is clear from Mandaya's flow records (Table 4.5) that the duration of first filling period will be a key issue for future assessment, and require the closest collaboration among the three countries because satisfactory releases downstream must be made during the first filling period. This is a work area requiring very detailed cooperative studies.

It may be noted that the pre-feasibility design of the dam provides for diversion conduits during construction. Two of these would be converted to low level outlets and be capable of discharging more than the project's future regulated dry season flow. This physical capacity is built in to make large downstream releases during initial stages of first filling. Higher up the dam, at about EL. 640 (100 m below MOL), there will be mid-level outlets, also capable of discharging more than the project's future regulated dry season flow. These will take over from the low level outlets as the dam is progressively raised. They will remain for use in the operational period, although use of them, though available and possible, is not foreseen.

The cooperative studies required for determining release patterns during the construction period, and for the operation period, concern the hydrology of the whole Nile system and demands on it. This is a big work area, requiring high standards of river gauging records (so that all may agree) and more information on existing and future water demands – magnitudes, seasons and return flows.

6.3 PHYSICAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.3.1 Soil Erosion, Water Quality and Air Quality at Construction Sites

Environmental protection and remedial measures during construction against soil erosion, and for water quality and air quality at construction sites, are foreshadowed in the above section relating to the activities of the project construction contractors.

6.3.2 Water Resources Impacts

The physical impacts of successive cofferdams and reservoir first filling are described in Section 6.2 and Table 6.2.

Mitigation

There is no alternative to diverting the river for dam construction and no mitigation for dessicating the river channel at the dam site.

The backwater effects of the upstream cofferdam will have varying impacts on upstream water levels. Biological and socio-economic impacts arising from these require mitigation measures before river diversion; in principle, but not in geographical extent, these impacts will mirror the impacts which will occur during reservoir impoundment.

Mitigation measures will be required to be carried out by the contractor for cofferdam operation and reservoir impoundment according to the project's EMP. Various biological and socio-economic impact mitigations are discussed later.

6.3.3 Water Quality Impacts

There is insufficient data available on Abbay water quality, soils and residual biomass in the Mandaya reservoir area (736 km^2) to assess impacts on water quality from the time of and after first filling.

Mitigation

Measures to remove woody vegetation from the reservoir basin are discussed under biological impacts below.

A water quality simulation model will be required to assess seasonal changes in reservoir water quality and project design and management strategies to minimize adverse changes. For this model, data from future water quality sampling, soil sampling and biomass studies will be required.

6.3.4 Sedimentation Impacts

Reservoir sedimentation will begin during first filling in the construction period and continue throughout the life of the project. Current sediment transport rates are unknown but indications are that the average annual rate may be 285 Mt/year, and increasing. The most serious impact of sedimentation is that it will progressively reduce live storage capacity and firm yield thus reducing energy generation and sales at Mandaya. Similarly, the initial benefits of uplifts in energy generation downstream will decrease. Another impact is that the annual dressing of silt given to cultivated alluvial areas (as a free fertilizer) along the Blue Nile and the Main Nile will be reduced and channel morphology changes will be induced (Chapter 7).

Mandaya dam spillway levels, unlike those of Roseires and Sennar dams downstream, are too high to permit flushing of sediment-laden flood flows through the structure – the mitigation measure used at Roseires and Sennar. Bed load, and coarse and medium size suspended sediment loads will therefore be trapped and retained in the reservoir – initially some 250 to 300 km away from the dam in the Abbay arm of these reservoir, but somewhat nearer in the Didessa arm. Once these loads are received in Mandaya reservoir, there is no mitigation. The positive impacts of this are that Roseires, Sennar and Merowe hydropower projects and irrigation intakes and canal systems in Sudan will operate more effectively whilst sedimentation rates at these dams and at High Aswan Dam will be reduced.

Mitigation

There is no known economical and practical mitigation measure for removing silt from large reservoirs to recover significant quantities of their original storage capacity.

Great efforts are needed to reduce sediment transports rates of Abbay and Didessa in upstream catchment areas before entering Mandaya reservoir, and the sediment transports rates of Abbay’s main and minor tributaries that feed directly into Mandaya reservoir. Implementation of a watershed management program is required for this, as being prepared by relevant regional governments and ENTRO. This is one of the most challenging areas of work in the Abbay river basin.

The developing watershed management program for the Abbay basin has not been finalized. Cost estimates and sources of finance for its implementation are not yet known.

The Mandaya project could, and it is believed should, have a very significant role to play in the watershed management program for Abbay. The Abbay watershed management program is required regardless of the Mandaya project. With the Mandaya project, the program becomes even more vital. The mechanism for Mandaya project contributing to watershed management could be through its financial support, from energy sales. This is the view taken at Nam Theun 2 in Laos, where USD 1.0 million per year from the energy revenue stream is allocated to conservation of Nam Theun’s watershed and contractually guaranteed for 25 years. In this way, knowing an annual budget and contractual commitment to it over a long period, programs can be developed with full consultations with local communities.

This contrasts sharply with past approaches based on inadequate and short-term budgets.

6.3.5 Reservoir Slope Stability

Precambrian rocks underlie the entire reservoir area of Mandaya dam. This is fundamentally favourable for slope stability. Undercutting of basalt cliffs where they are underlain by weak, easily 'erodeable', Miocene sedimentary rock often causes landslides in the Abbay gorge. Landslides may also occur in saturated zones of sedimentary rock, especially gypsum and mudstone. Both of these adverse geological environments are absent in the Mandaya reservoir area.

Examination of the available geological maps confirms that Basement crystalline rocks underlie the entire basin, with granite types more prevalent than schist types. The foliation of the rock is generally steeply dipping usually in the range of 80 to 90 degrees, and joint sets are usually vertical or sub horizontal, but never inclined. This arrangement is quite favourable for slope stability.

The Mandaya reservoir divides into two separate branches: the Abbay branch and the Didessa branch. Concerning the latter, gentle slopes and favourable geology typify this part of the basin, and the risk of large scale instability after impoundment, is low.

Concerning the Abbay branch, it is considered that the worse case scenario occurs within Mandaya Gorge itself, from the dam wall to a point 7 km upstream. In this section there occurs maximum depth of water, very steep side slopes, and vertical cliffs along the basalt cap rock, with the possibility of weak palaeosoil/conglomerate separating the basalt and underlying Precambrian rock. Air photos indicate no landslide along these slopes. Field inspection suggests very shallow soil cover with gullies exposing decomposed gneiss. Small colluvial fans are found at the base of these gullies, but these are formed during flash floods and by slope ravelling. The existence of huge perched blocks of basalt indicate toppling due to undercutting. Some blocks have rolled down to river elevation. The slopes appear to be quasi stable, with possibility of basalt blocks toppling and sliding under extraordinary conditions, such as during seismic events, or under adverse weather conditions. The question to be posed here is how the quasi stable condition might be altered for the worse following permanent inundation? To analyse this question it would be necessary to get data on the depth of weathering of the gneiss, the frictional properties of the soil cover and gneissic regolith, and the precise condition of the basalt/gneiss contact, as well as the precise slope morphology. The overall geological environment appears to preclude a huge scale slope failure as the weathered gneiss layer appears to be limited in depth. The contact of the basalt/gneiss is above the FSL of the reservoir, however it must be considered as possible for blocks of basalt to be dislodged during the life of the dam, and such blocks might be up to 1,000 m^3 in volume, as mentioned earlier. If these blocks fell onto the dam wall during or after construction, this could cause great damage. So prior to construction it would be prudent to trim-of the basalt cliff above the dam working area, and to closely inspect any existing, perched, detached basalt blocks.

Very steep slopes tower above the Abbay branch of the reservoir in a section upstream of the point where the river intersects longitude 36 degrees 10 minutes.

This point is about 70 km upstream of the dam. According to the 1 to 1 million scale geological map of Ethiopia, the extreme topography in this area coincides with a gneissic granite intrusion. In fact there must always be a direct relationship between steep, high, slopes and favourable bedrock geology. Nevertheless, this area should be checked during the feasibility studies, and so should other similar stretches which occur even further upstream. Here it is merely noted that any bow-waves created by landslides in these zones would be quite attenuated by the time they reach the dam wall.

Mitigation

Under the circumstances of favourable geology, the risk of slope instability following impoundment appears to be low. Site investigations during feasibility studies should investigate the various potentially adverse features described and recommend any necessary precautionary works to be carried out in the construction period.

6.3.6 Groundwater and Reservoir Seepage

There is considered to be low risk of reservoir leakage at Mandaya. The shortest possible seepage path occurs at the dam on the right bank. This seepage path from the reservoir to the north is 2 km long. Along this seepage path, which is 120 m below ground surface, the basement gneiss will be unweathered and therefore will have very low rock mass permeability and zero porosity.

Groundwater levels in areas that favour groundwater may be expected to rise with reservoir impoundment. However, generally, as discussed above, areas adjacent to Mandaya reservoir have rock types and structure unfavorable for seepage and groundwater supplies.

6.3.7 Reservoir-induced Seismicity

The Mandaya dam project area is located in a relatively low seismic hazard zone. It is outside of the seven recognized seismically unstable active zones of Ethiopia. No analysis of reservoir-induced seismicity has been made in this study but for such a large dam as Mandaya such analysis will be needed during feasibility investigations.

6.3.8 Impacts on Minerals

On first impoundment in the construction period, Mandaya reservoir will inundate an area of 736 km^2. The main river and tributaries may have reaches containing alluvial gold, and therefore this renewable resource will be lost to the people living in adjacent areas.

The impoundment will also stop any gold being transported and deposited in alluvial deposits downstream of Mandaya dam as far as Roseires reservoir. It is assumed that Roseires is the downstream limit of this impact because Roseires dam itself will have had the same impact.

No other known valuable minerals are affected. Marble deposits are being worked currently are downstream of Mandaya dam and will be unaffected.

Mitigation

There is no mitigation for impounded alluvial gold deposits except compensation payments for any communities engaged in gold panning. Our social surveys did not reveal much interest in these activities in the Mandaya area.

Although there is and will remain great uncertainty about the quantity of alluvial gold extracted from Abbay downstream of Mandaya, and from tributaries of Abbay downstream of Mandaya, social surveys noted the importance of gold panning for many people in these areas – in Sirba Abbay, Wonbera and Guba woredas. Much of the gold panning is in tributaries of Abbay downstream of Mandaya that would be unaffected by Mandaya; these same downstream tributaries may be expected to deliver some of the alluvial gold which is panned in the Abbay. However, some of the downstream alluvial gold of the Abbay river itself may be expected to have passed through the Mandaya dam site which will cease in future. Consideration will require to be given to compensating the downstream gold panning communities for loss of this part of the resource.

6.4 BIOLOGICAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.4.1 Clearing Vegetation (small scale)

Environmental protection and remedial measures relating to clearing vegetation on each construction site (mainly roads, dam, quarries, borrow areas, power house and switchyard sites) has been foreshadowed in Table 6.1.

6.4.2 Clearing Vegetation (reservoir basin)

Clearing of woody vegetation from the reservoir basin will be required in the construction period before first filling the reservoir. Clearing of some or all areas will avoid or minimize water quality problems and trash problems during the operational period and should benefit future reservoir based activities: fishing with nets, boat operators. Furthermore, standing dead trees are very unsightly and clearance will improve the new landscape aesthetically.

The degree to which the reservoir should be cleared is uncertain. The general assessment of biomass conditions concluded that the database was not adequate to make a preliminary estimate of the volume of standing timber and related root biomass below ground (although a rough estimate was made for estimating CO_2 emissions, Appendix 6.1). Such estimates would require detailed traverse surveys throughout the potential reservoir basin. A water quality simulation model will also be required to estimate the consequences of clearing minimal to maximum areas of woody material, with and without de-stumping to remove residual stump and root biomass.

The initial dead water storage capacity at Minimum Operating Level (MOL) at Mandaya will decrease as it (and some live storage volume) becomes progressively silted in the operational period. The surface area (500 km^2) associated with MOL will provide the aquatic habitat in the months when the reservoir is fully drawn down. The water below the surface at MOL is likely to be anaerobic most of the time, as *in situ* matter decays and falling matter from higher elevations in the reservoir is received and decays. On very rare, perhaps emergency occasions, when some of this water may be required downstream (passing through mid-level outlets without being turbined), releases of this anaerobic water may spoil aquatic life, including fisheries and livelihoods dependent on fisheries, in the Blue Nile and reservoirs at Roseires and Sennar. Depending on results of water quality modeling, and an assessment of the need for discharges from the mid-level outlets in the operational period, this report therefore anticipates that most woody vegetation in the dead storage zone may require to be cleared.

Experience elsewhere has shown that total clearance of woody vegetation in the live volume areas of reservoirs is unnecessary and that some advantages accrue to aquatic life from residual woody habitat in this zone, including its provision of breeding places and hiding places for small fauna including juvenile fish.

Owing to the very steep topography of valley sides, and there being no existing roads in the Mandaya reservoir basin area, most areas are inaccessible. It is almost certain therefore that contractors will not be able to achieve total clearance of woody vegetation, even if contractually required to do so.

As local demands are not heavy for fuelwood and charcoal and these are satisfied locally, there is no obvious local market for the cleared timber. Transport costs over difficult terrain and long distances will be high, probably causing distant markets to be uneconomic to supply. In the riverine vegetation, there may be some tree species with high economic value that would attract contractors but the areas of this are miniscule.

It seems possible that an attractive procedure could be to award contracts in some areas (as in forestry “compartments”) for tree clearing, with felled timber being stored a short distance beyond the reservoir’s full supply level, i.e. hauled above the future reservoir’s perimeter. These wood stores would then be utilized by local communities prepared to collect timber from them, or remain *in situ* as decaying woody micro-habitats. However, the valley side slopes are generally steep or very steep and in many areas this may not be practicable.

An alternative could be to cut and float timber downstream to “collecting points” where vehicular access may be practicable. This is not attractive from an engineering point of view as timber not collected would arrive as trash loads at the dam construction site and could cause problems at the diversion conduits, and for Roseires downstream.

Burning timber, excepting for domestic use, is generally not permitted in Ethiopia. Further consultations might reveal that in certain circumstances, perhaps with a special licence, limited burning may be permitted. If this is the case, as a last resort and for contingency purposes, there may be merit in pursuing this. There could be several or many areas in Mandaya’s reservoir basin where it is impracticable to remove woody stems, residual branches and other materials to locations outside the reservoir perimeter. The quantities might be very considerable. The benefits of this “tidying up” by burning, notwithstanding smoke and residual ashes, might be considered preferable to these materials rotting in water in future years, or floating and adding to hazards for boats, fishing and trash rack operations at the power station intakes at Mandaya and dams downstream.

Mitigation

Reservoir basin clearance can be a difficult activity even when terrain conditions are favourable. At Mandaya, conditions are as difficult as can be imagined anywhere.

One or more specialist or local community contractors may develop Mandaya reservoir clearance plans. Nothing should be decided without seeking the views and having full consultations with contractors, local communities and woreda administrations. Having made this point, the project's EMP concerning reservoir basin clearance will cover the whole reservoir area or "compartments" to ensure that whatever mechanisms are decided for clearance, a realistic timeframe is declared, understood and agreed, taking into account seasonal ground conditions for operations, local labour availability and its other seasonal commitments, and other factors.

Emergency contingency measures should also be formulated, especially for clearing the dead storage zone (if recommended). This is because once filled with water on first impoundment, the opportunity to clear this area does not occur again. Various reservoir projects have suffered in this regard, where project management or professional or community contractors failed to mobilize effectively before it was too late.

In preliminary costing of reservoir clearance, we have based costs on unit area rates adopted for Karadobi adjusted by + 20% for greater amounts of woody material at Mandaya (Table 6.3). This will not be satisfactory in future studies when both area and tree density and timber volume data, obtained from future surveys, should be considered in consultation with regional government, woredas and potential contractors. Again for preliminary purposes, we have adopted the full reservoir area less estimated river water surface area and a small other area, resulting in clearance of 90% of the total reservoir area. As noted above, this area may be reduced when further detailed information becomes available from reservoir water quality modelling and when more consideration is given to residual micro-habitats for aquatic life, burning and the physical practicability of removing cut vegetation.

Table 6.3 : Mandaya Reservoir Clearance Costs

Reservoir area to be cleared ha	Rate USD/ha	Cost USD million
66,100	600	39.66

The project's EMP will require careful preparation following detailed vegetation, wildlife habitat and wildlife surveys, and following water quality modelling. It needs to be implemented by the contractor(s) in consultation with the Owner, EMU, regional government and woredas. The realities of how timber (or community) contractors work, and may work, should be reflected in the time-schedule of the EMP for reservoir basin clearance.

6.4.3 Residual Vegetation and Reservoir Impoundment

During first filling, loose residual woody material, and other floating materials, will cover parts of the reservoir. Depending on wind directions, these will accumulate in bays and may be redirected according to seasons. Subject to further checking locally, northeast winds prevail during the dry season (gathering floating materials on southwest shores) and westerly to southwesterly winds occur during the rains (gathering floating materials on eastern and northeastern shores). When drawdown occurs during first filling (and in the operational period), some materials will be temporarily deposited until lifted again. None of this material can escape from the reservoir until such time as the spillway operates, when water currents and winds may direct materials to the dam, power station intake and spillway. Booms will control and divert floating materials and trash racks will remove materials at the Mandaya intake. Trees, shrubs, dead animals and other materials which pass through the spillway will eventually be received in Roseires reservoir. This cycle then repeats itself at Roseires, Sennar and Merowe dams and at any other existing (or future) structures/intakes downstream.

Potentially, such quantities of floating and semi-submerged materials (in addition to the normal trash load carried by the Abbay and tributaries) could be troublesome at Mandaya dam and at structures in Sudan downstream. Costs of remedying these problems are not insignificant.

Mitigation

Mandaya reservoir basin clearance needs to be effective. This aspect relating to dealing with additional trash at Mandaya, and at Sudan's river structures, from Mandaya's reservoir basin clearance and first impoundment, requires to be fully considered in future studies with mitigation measures being included in the EMP.

6.4.4 Terrestrial Fauna

During clearance of the reservoir basin, most of the tree habitat, and shaded habitats in lower layers of shrubs and grasses, will be destroyed. This loss of terrestrial habitat is unavoidable with such a project. In due course, some of the area (the dead storage zone) will be permanently under water. Finally, the live storage zone will be inundated. Terrestrial fauna that cannot escape will therefore be decimated.

Mitigation

Directives for construction workers concerning wildlife conservation and protection are foreshadowed in Table 6.1.

The EMP for fauna will be required for the whole reservoir and surrounding areas. Information on wildlife is currently too scanty and inadequate to anticipate remedial measures in specific terms. The plan will be drawn up in consultation with local communities, relevant wildlife departments and NGOs following detailed vegetation and fauna surveys.

The EMP will, *inter alia*, need to take into account, through consultations, all wildlife matters which local communities may fear. When reservoirs are filling for the first time, local residents typically fear an influx of snakes. They may also fear fatalities or injuries, or spoiling of crops, arising from movements of animals such as hippopotamus and crocodiles.

The EMP will also need to take into account the possible need for animal rescue, particularly if future surveys (with better topographic mapping than is currently available) indicate that temporary or permanent islands will be created by impoundment.

The wildlife EMP will also need to recognize the potential importance of the lower Dabus Valley and include a plan for its monitoring and management. This is discussed below.

Mitigation – Environmental Offsets – Lower Dabus Valley and other candidates

As mentioned earlier, consideration should be given to the detailed vegetation and fauna surveys of Mandaya reservoir including all of the lower Dabus Valley controlled hunting area where survey results may assist regional government and the Ethiopian Wildlife and Natural History Society in determining the status of the area regarding its future designation as an Important Bird Area (IBA). This would not only make a worthwhile contribution to the Society but the results might lead to the Mandaya hydropower project owner adopting the lower Dabus valley as an environmental offset, in full or part mitigation for the destruction of habitat in Mandaya's 736 km^2 reservoir basin, quarry sites and other disturbed areas.

Whilst our scoping of issues has suggested Dabus valley as being a potentially suitable candidate for attempting to offset loss of woodland and grassland habitats in Mandaya reservoir and associated works areas (including transmission line towers and any clearings of woodland habitat for stringing towers along the Right of Way), in further studies other candidates should be considered in addition to Dabus. For example, if future wildlife habitat and wildlife surveys indicate significant migration movements for which the new reservoir will present a permanent barrier, and make such animals more susceptible to poaching, a management plan for the surrounding areas may be appropriate, followed by financial support from the project for implementing this plan.

6.4.5 Terrestrial Ecological and Biomass Surveys

From this basic assessment of flora and fauna, it is evident that thorough ecological surveys are required in order to greatly improve impact assessment and to contribute to developing a competent EMP. It is considered that these surveys will occupy at least two years.

It is noted that vegetation surveys in particular must be carried out in months following the rainy season when foliage assists identification – not in dry seasons when deciduous trees have lost their leaves and when fire affects many areas. At such times, the ENTRO survey boat, first used in March 2007 at Mandaya, may be of great assistance in permitting systematic transect surveys along Abbay and Didessa from the Boka and Mandaya dam site end, and from Nekemte-Bure bridge in the east. At planned locations, transect surveys should proceed "inland" from these rivers to the Mandaya reservoir perimeter and some distance beyond the perimeter.

To assist planners later, these surveys should cover the reservoir, reservoir margins and works areas, and potential candidates for environmental offsets.

In the project's full EIA report, if endemic or threatened plant or animal species are found, it will be important to state with confidence, if possible, that these species are found, or are not found, in adjacent areas. With regard to bird and bird habitat surveys, experienced and trainee ornithologists should be commissioned, and their survey efforts ensure that all seasonal aspects are covered. For this the assistance of BirdLife International might be sought. This organization is greatly experienced in bird surveys, bird habitat conservation measures and designating IBAs and is already collaborating with the Ethiopian Wildlife and Natural History Society.

These transect surveys should also establish baseline data on biomass and soils (for use in the water quality model later). The surveyors should also pay attention to the reservoir basin clearance issue and, in the course of surveys, consider practicable options for removing woody material.

6.4.6 Aquatic Fauna

When the first and then the second upstream cofferdam is constructed, an area of river channel, river banks and adjacent land will be flooded in the high flow season. Flows will be diverted, to permit dam site construction works, and be released in the Abbay channel downstream of the downstream cofferdam. Changes in aquatic life are expected during this time as the habitat changes temporarily, from a running river to a lacustrine environment, then back to running river as levels fall.

During the first impoundment of Mandaya reservoir, major changes may be expected to begin and continue until species suited to a reservoir aquatic environment are established. Fish species that will be affected are listed in Appendices.

Although there is not yet clarity about which of the 29 fish species in the Blue Nile (Mishrigi, 1970) migrate from the Blue Nile and Roseires reservoir to the Abbay, Beles and Dabus and to smaller tributaries for spawning (i.e. through the Mandaya reservoir reach), it is clear that the Mandaya dam will permanently stop upstream migrations during the construction period.

Mitigation - Aquatic surveys and Fisheries Development

It was earlier noted that baseline information on phyto-plankton, zoo-plankton and benthic fauna in the Mandaya region is scarce and that information on fish, whilst better, is not adequate to assess project impacts comprehensively. From what is known, there are no endemic aquatic species so far reported from the Mandaya dam site and reservoir area but it was noted that this assertion is based on incomplete baseline data and that rare species, with restricted range distributions, are not easily sampled and brief surveys can easily miss them.

There is a developing aquatic database for Abbay and a good aquatic database for the Blue Nile and Roseires and Sennar dams, and much may be learned from these to assist planning of surveys and assessment of Mandaya's impacts. The University of Khartoum's Hydrobiological Research Unit intensified investigations from 1963 when Roseires was under construction, and provided for the first time in the Nile system a study of biological impacts of a major dam on 640 km of river before and after construction (Hammerton, 1972, 1973, 1976; Moghraby, 1972, 1979). Learning from the Roseires research experience is believed to be essential in future impact studies because of Roseires' geographical proximity to Mandaya, and because Roseires receives flows, water quality and sediment loads practically identical to a future Mandaya reservoir. Indeed, as impact assessment of Mandaya must consider Mandaya's impacts on Roseires and the Blue Nile and Main Nile, it will be essential that future aquatic studies are collaborative and lead to realistic assessments of Mandaya's fisheries development potential. According to information available from FAO (2001), Roseires reservoir has a potential of 1,700 tons/year and fish landings of 1,500 tons/year (88%) from a surface area of 290 km^2. 22 fish species, 1,200 fishermen and 550 boats are reported to be involved.

Thus, this scoping report identifies an inadequate but improving aquatic database for Abbay surrounding the Mandaya site but a potentially rich source of knowledge at Roseires in Sudan. Further surveys and studies will be needed to assess impacts in the construction (and first filling period) and operational phases. These aquatic surveys may be expected to improve knowledge of fish species, migrations and other characteristics but also contribute to development of a policy for clearing of woody biomass in Mandaya reservoir prior to first filling – in particular, with regard to substrates useful for aquatic life, areas where stumps should, or should not be cleared, or be only partially cleared (if indeed there is any choice in this matter).

The EMP regarding aquatic life and fisheries development will be required following future water quality and aquatic surveys, and following results of water quality modelling and review of Roseires' database. These surveys are expected to take at least two years.

Mitigation – Barrier to fish migration

Fish passes, and Borland fish lifts, are not considered feasible mitigation measures for assisting upstream fish migration for a number of reasons. The principal reasons relate to Mandaya's dam height (200 m) and the wide range in reservoir water levels. On the latter, it is difficult to engineer delivery of fish to a 40 m range of water levels. On the fish biology side, there is no known research data on swimming characteristics of fish species in the Abbay/Blue Nile that would assist engineering design; elsewhere, lack of specific data has rendered fish passes, designed on successful models in other regions, useless.

Only detailed surveys will reveal which fish migratory species may die out in the Abbay, if any, owing to the Mandaya dam barrier to migration. Following detailed surveys and comparisons, it should be possible to estimate (particularly from Roseires' experience) which fish species may flourish in Mandaya reservoir under its operating conditions and to prepare a plan to exploit fisheries sustainably.

6.4.7 Disease Vectors

Reservoir impoundment will increase the surface water area and create a larger conducive environment for disease vectors, especially mosquito breeding.

Mitigation

Mitigation measures are required in terms of health education, making available mosquito nets and provision of health care clinics with adequate staff and materials for screening and treatment. The EMP, and the contractor's response to it, should cover the workforce and camp followers. The project will need to boost these services in any settled areas surrounding the reservoir and for host and resettlement communities (described later).

6.5 SOCIAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.5.1 Summary

Our assessment indicates that there will be some loss of resources and income generation opportunities in the direct impact zone of the Mandaya hydropower project but fortunately these are on a small scale relative to the size of the project and project area.

Moreover, use of natural resources and an area of flood recession agriculture will be lost due to the reservoir. In addition, a relatively small area of land and property will be lost due to construction activities.

There will also be temporary negative effects for local people caused by increased turbidity and possibly chemical pollution of local water sources during construction of project roads, the dam and ancillary works.

All of the above will require mitigation actions in the form of compensation, resettlement and environmental protection measures. In addition, an extensive livelihood safeguard program should be developed to improve the well being of affected people and the host communities. In other words, it is believed that development of a Resettlement Action Plan (RAP) should not only include provisions for resettlement and host communities but for development of the area.

Some few impacts are foreseen between Mandaya dam site works area and the Sudan border owing to construction activities, assuming satisfactory water releases will be made to Abbay/Blue Nile during the reservoir first-filling process. However, these downstream release rates during first-filling will impact on Sudan and Egypt and will require very careful assessment, as they will for the operational period, because of the vast population, culture and economy which depends on the natural Abbay/Blue Nile flow regime.

6.5.2 Principles of Compensation

The principles of compensation which apply in Ethiopia are summarized as follows.

1. Compensation for lost property will be in line with the Proclamation No. 42/1995;
2. Compensation and entitlement provided to the project affected people (legal and illegal) should ensure that the life of the people and host communities are improved or at least the pre-project living standards are maintained;

3. Temporary displacement shall be kept to the minimum;
4. Land replacement (allocation) should be sufficient to maintain the livelihood of project affected people (PAP);
5. PAP should be informed about the project including impacts of the project, eligibility, compensation rates and income restoration, etc;
6. All public property affected will be paid in cash to the owner of the property and replacement shall be made to the communities;
7. Special attention will be given to vulnerable groups such as female household heads, the sick, aged, extremely poor and other disadvantaged groups.

6.5.3 Loss of Housing, Shops, Public Building, etc.

Population density in the project area is low and the settlement pattern is highly dispersed. People lead a traditional way of life and there appear to be no formal markets or associated facilities like stores and other buildings in the areas affected by dam construction and reservoir impoundment.

Communities with an estimated 600 inhabitants comprising 120 households are estimated to be living within the reservoir area. The affected woredas are Yaso in Benishangul Gumuz and Wonberma in Amhara region.

It is estimated that about 1,020 people comprising 204 households in villages immediately downstream of the dam site will be affected by dam construction activities. These villages are in Sirba Abbay woreda.

In all cases, each household can have 2 to 4 houses depending on their wealth. Taking three houses per family, the total number of houses requiring replacement will be 972. There are no other social facilities in the project area. Compensation estimates for houses is given in Table 6.4.

Table 6.4 : Summary of Lost Assets and Compensation

No.	Social Structure	Unit	Unit Cost	Quantity	ETB
1	Houses in reservoir area	No.	600	360	216,000
2	Houses in construction area	No.	600	612	367,200
Total			**600**	**972**	**583,200**

6.5.4 Arable Land Compensation - Construction Areas

Estimates of compensation for crops lost from arable land required for permanent construction sites, excluding the reservoir and transmission lines, are given in Table 6.5.

Table 6.5 : Compensation for Arable Land at Construction Sites

Construction Activity	Cultivated Area required ha	Unit cost ETB/ha	Annual compensation ETB/year	10 years compensation ETB
Access roads	40	25,149	1,005,960	10,059,600
Works areas	54	25,149	1,358,046	13,580,460
Total	94	25,149	2,364,006	23,640,060

6.5.5 Transmission Lines

It is proposed that transmission lines will be routed to either Hasaheisa or Rabak in Sudan and to either Debre Markos or Sululta in Ethiopia to connect with national grids respectively (Figure 6.1). Impacts will be related to construction of transmission line towers, stringing, construction camps, stores, access tracks and other structures. For each transmission line, a 40 m wide Right of Way is assumed at this stage of pre-feasibility planning. None of the specific route alignments have been inspected on the ground for this study. Consideration has been given to them by general knowledge of the areas and land uses based on aerial surveys in October 2006 and site visits to and around the Mandaya project area, and observations made from road routes, various maps and satellite images. Also, reference has been made to the reports on the Ethiopia-Sudan Power System Interconnection study (SMEC, 2006).

Mandaya to Hasaheisa or Rabak

The transmission line route from Mandaya to Hasaheisa (650 km) generally follows a northerly alignment. There will be limited impact on settlements and cultivated land due to construction of the transmission line from Mandaya to El Damazin which passes Roseires reservoir on its western side. From El Damazin, the route follows the main road system to Hasaheisa via Sennar, keeping therefore to the west of the Blue Nile. Impacts on settlements and cultivated land may be expected to increase along this route and as it approaches Hasaheisa.

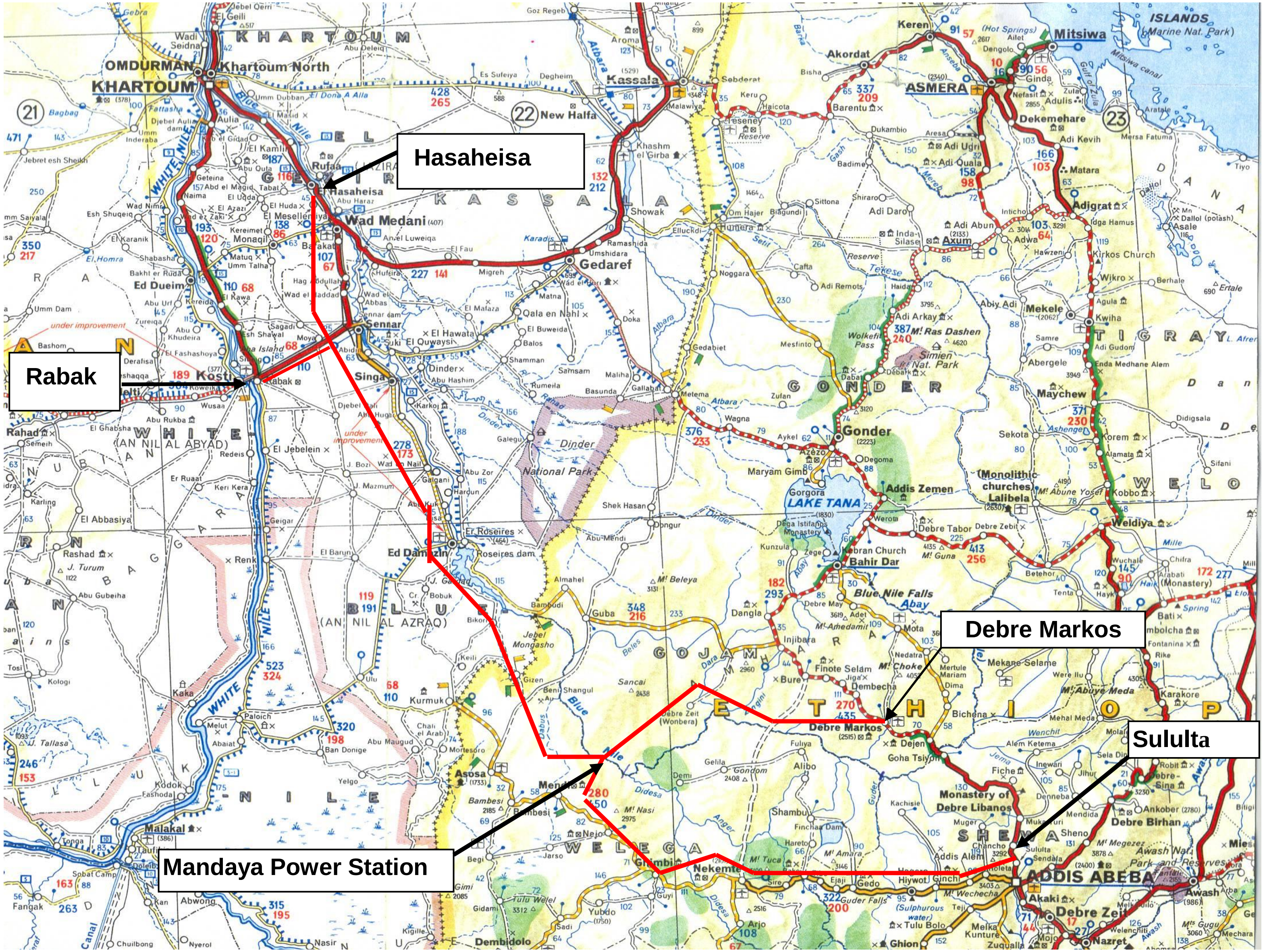


Figure 6.1 : Transmission Line Routes Mandaya to Hasaheisa/Rabak, Debre Markos and Addis Ababa (Sululta)

The route from Mandaya to Rabak would follow a similar route as far north as Sennar but then turn WSW following the road and rail corridor to Rabak. The latter distance would be marginally shorter (about 5%) than Sennar to Hasaheisa but the route of this final section is considered preferable owing to the high population density and difficult ground conditions near Hasaheisa. The Sennar-Rabak section passes through black cotton soils, as does the Sennar-Hasaheisa section, but through more semi-mechanized farms and less irrigated land. As with other transmission line alternative routes, the preferred technical options were not resolved and clear at the time of report preparation owing to further study being required in relation to Module 6 – coordinated investment planning.

Mandaya to Debre Markos

The direct transmission line route from Mandaya to Debre Markos (240 km) is not acceptable. It would follow an easterly direction through very difficult terrain, with woodland and shrublands and low population density, crossing over the middle reaches of the Abbay arm of Mandaya reservoir on three occasions, until passing over Abbay for a fourth occasion in the potential Beko Abo reservoir area. After leaving the Abbay gorge, the remaining 50 km would be along the cultivated plateau to Debre Markos. Along the entire route, there are no existing west-east roads for the route to follow and to assist construction, but the Nekemte/Bure road would assist access and construction in the central section. It appears unlikely that engineers would wish to negotiate the difficult terrain of this route and would prefer to construct the line along the plateau. On environmental and engineering grounds, three crossings of the Abbay arm of Mandaya reservoir are not recommended.

A route slightly to the south has been considered. This would be assisted by some tracks and also by access from the Nekemte/Bure road. It would be a little longer at 255 km. However, this route is impracticable because of the need to cross the wide expanse of the Didessa arm of Mandaya reservoir. This route would need to pass further south before crossing the Didessa, making the route considerably longer.

A route further north may be considered This route could be influenced by a decision to link the new Mandaya bridge, required for dam construction project purposes and which would cross Abbay downstream of Mandaya dam, to Wonbera (Debre Zeit) to the northeast. This route to Debre Markos would be longer than others mentioned.

If a Mandaya to Debre Markos route is selected on technical grounds, current transmission studies indicate that works will be required along the existing Debre Markos to Sululta route.

As the interconnection position with the Ethiopian grid (Debre Markos or Sululta) has yet to be decided on technical grounds, for the purpose of this report and on environmental grounds the route to Sululta is preferred, though it is much longer.

Mandaya to Sululta

The transmission line route from Mandaya to Sululta (450 km) would first follow a southern alignment to join the main Mendi to Addis Ababa road, and then follow the main road eastwards. The shortest length for the first section (Mandaya to main road) would join the main road near Nejo. The terrain is difficult and without roads except for some 20 km of existing tracks leading northwards from Nejo.

Alternatives for this first section would be to follow project roads from Mandaya in a southwesterly direction to Mendi (a longer route) or to follow a southeasterly route from Mandaya to Hagelo Meti where a track leads to the Nejo-Gimbi section of the main road. This route length would be similar to the one to Nejo.

The basis for estimating compensation for Mandaya project's two transmission lines is the Ethiopia-Sudan Power System Interconnection study report (SMEC, 2006). The consultancy services for the SMEC report required the preparation of an EIA and two RAP reports (one for Sudan and one for Ethiopia) in accordance with the requirements of the Ethiopian and Sudanese Governments and the World Bank which provided funds towards the investigation. The Project was classified as a category "B" project under the Bank's environmental procedure (OP/BP 4.01 Environmental Assessment) so that an EIA (including an Environmental Management Plan) and Resettlement Action Plan (RAP) were required.

The EIA and RAP studies considered three route options. The nearest of these routes to Mandaya, and therefore most similar in land use and settlement conditions, is Option B1. Compensation rates for the two sections of Option B1 are given in Table 6.6.

Table 6.6 : Ethiopia-Sudan Interconnection Compensation

Transmission Line ROW 40 m Option B1	Length km	Total Compensation USD	Total Compensation USD/km
In Ethiopia Debre Markos-Injibara-Sudan border	366	2,137,263	5,840
In Sudan Ethiopian Border to Roseires	82	118,140	1,440
Whole Line	448	2,255,403	5,030

Source: Ethiopia-Sudan Power System Interconnection (SMEC, 2006)

The higher compensation rate (USD 5,840/km) provides for the line passing through open shrub and open woodland, and through continuous, intensively cultivated areas with significant impact on households, farms, woodlots and Eucalyptus plantations. The lower rate (USD 1,440/km) provides for the line passing through open shrub and open woodland and very little impact on settlements and cultivation.

The loss of cropping along routes will not be permanent, excepting for the very small cumulative area occupied by towers. Crops may be lost for one year, perhaps two at most, owing to clearing of the 1 x 40 m right of way (ROW) and stringing the conductors. Cultivation of land and income from crops should be restored following these activities. Thus, in this case, compensation has not been based on 10 times the annual lost value of crops.

The difference between the unit compensation rates is about a factor of four. In both cases, various compensation conditions are taken into account within the high and low rates. For first estimations of compensation for Mandaya transmission lines, these high and low rates have been adopted as given in Table 6.7. (For the Mandaya to Sudan line, the table gives length and compensation estimate to Hasaheisa; to Rabak, the compensation may be fractionally lower because of slightly shorter distance).

Table 6.7 : Mandaya Transmission Lines Compensation

Mandaya HPP Transmission Lines	Transmission kV	Length km	Total Compensation USD/km	Total Compensation USD
Mandaya HPP to Hasaheisa/Rabak (Sudan)	500	650	50% @ 1,440 50% @ 5,840	468,000 1,898,000 (Total 2,366,000)
Mandaya HPP to Sululta	400	450	30% @ 1,440 70% @ 5,840	194,400 1,839,600 (Total 2,034,000)
Both Lines		**1,100**		**4,400,000**

Some additional points are noted from the SMEC report. One of greatest concerns of the Consultant was how to achieve local support for transmission lines when no local project benefits in the form of local electrification can be demonstrated. It was considered that providing local electricity to people affected by the transmission line projects (either directly through the financing of local distribution lines, or indirectly, by reinvesting a proportion of the economic benefits of the project into rural electrification), the project would enhance overall poverty reduction and rural development efforts in the two affected countries.

Electricity supplied to rural towns would replace/reduce the consumption of woody biomass and petroleum products used for cooking, lighting, and motive power. It would support development in the agricultural sector (irrigation pumps, poultry, animal husbandry, preservation of products); in the commercial sector (shops, bars, and restaurants); to small and medium industries (flour mills, rural water supply installations, tanneries, and coffee processing plants), to the residential sector (lighting, heating, and cooking), to education (kindergarten, elementary schools, junior secondary schools, secondary schools and technical colleges), and to the health sector (pharmacies, clinics, health centres and hospitals). In brief, SMEC considered the project would assist in the facilitation of economic growth in project affected areas and create long-term employment opportunities for the poor, including women, thereby increasing income levels and reducing poverty.

Neither SMEC nor we have studied or estimated costs of provision of rural electrification as a development activity along the routes of the interconnecting transmission lines. This is an area for further consideration in future.

6.5.6 Arable Land Compensation - Mandaya Reservoir and Villages in Sirba Abbay

Impoundment of Mandaya reservoir is estimated to permanently destroy approximately 790 ha under flood recession agriculture. Crops, prices, yields, areas under cultivation and estimated compensation costs are shown in Table 6.8.

Some of this cropped area is associated with the 120 households who will need to be resettled. However, an estimated 275 households who live outside of the reservoir area and whose properties will not be affected cultivate the majority of this land.

Table 6.8 : Reservoir Area Crop Compensation

No	Annual crop	Unit price	Average yield (qtl)	Crop Percent	Cropped area (ha)	Total Yield (qtl)	Total Cost	10 years Compensation
I	**Recession agriculture**							
1	Sorghum	170	13	49	387	5,031.00	855,270.00	8,552,700.00
2	Maize	150	20	25	197	3,940.00	591,000.00	5,910,000.00
4	Sesame	350	7	16	127	889	311,150.00	3,111,500.00
5	Vegetables	300	10	10	79	790	237,000.00	2,370,000.00
	Sub-Total			**100**	**790**	**10,650.00**	**1,994,420.00**	**19,944,200.00**

It is estimated that the area of cultivated land associated with the households in villages downstream of the dam site in Sirba Abbay woreda is similar. Thus, an additional compensation payment should be included, making a total of some ETB 40 million for 10 years' crop compensation.

Mitigation

The following is proposed as part of the mitigation measures:

- early notification and consultation with the affected farmers
- optimum siting of construction camps and other facilities, to minimize disturbance
- assess compensation rates fairly and pay expeditiously.

6.5.7 Grazing Areas

There is estimated to be a small but insignificant loss of grazing land because of project construction. However, this should be fully considered in future studies and planning.

6.5.8 Irrigation and Irrigation Potential

There is no existing or planned irrigated land in the Mandaya reservoir area.

During first filling of Mandaya reservoir, there is potential for water shortages to be created at existing irrigation schemes in Sudan and Egypt.

Mitigation

No mitigation is needed in Ethiopia. As mentioned earlier, a fully developed and agreed programme for reservoir first filling in the construction period is required to meet downstream irrigation demands (and energy generation) in Sudan and Egypt.

6.5.9 Infrastructure

There is no infrastructure in the Mandaya dam site area. Apart from the Nekemte-Bure bridge at the upstream end of the potential reservoir, there is no other infrastructure in the reservoir basin. This bridge will be unaffected.

A new bridge over Didesa river is under construction, connecting Kamasi and Yaso. This site is at the upstream end of the Didesa arm of the reservoir and should be investigated in the feasibility phase.

Mitigation

Currently, no mitigation measures are foreseen.

6.5.10 Patterns of Mobility and Navigation (roads and river crossing)

There are no known river crossing places in the Mandaya reservoir basin, except for the Nekemte-Bure bridge.

Mitigation

No mitigation measures are foreseen.

6.5.11 Resettlement

As part of the preparatory phase for construction, resettlement will be required for two groups of affected people – a total of 324 households with 1,620 people – as follows:

- in the Mandaya reservoir basin, communities with an estimated 600 inhabitants comprising 120 households. The affected woredas are Yaso in Benishangul Gumuz and Wonberma in Amhara region.
- In the villages affected by the dam construction activities, about 1,020 people comprising 204 households. The villages are downstream of the dam site in Sirba Abbay woreda.

In addition, some resettlement may be required in association with construction of transmission lines in Ethiopia and Sudan. Normally, this involves moving houses a relatively short distance from tower construction sites and the ROW.

An estimated 275 households located outside of the project area will lose their cultivated areas in the reservoir basin following first filling. It is not now considered that resettlement will be required for these households but future studies should assess the importance of these cultivated areas to the livelihoods of these households, and the impacts of the loss on their overall viability. Compensation has been provided earlier for the loss of crops but the RAP plan (and its updates) will need to cover these households as may be necessary.

Mitigation

In most cases, if not in every case, resettlement is required before construction begins.

In the case of the 120 households (600 people) in the reservoir basin, resettlement will be required prior to families being affected by backwater effects of successive cofferdams and the raising of the dam each, and ultimately before first filling towards the end of the long construction schedule. Depending on various arrangements, and elevations of settlements and cultivated land, it may be noted that very early resettlement may deny use of good resources unnecessarily.

In the case of Sirba Abbay villages, it is not certain that all of the estimated households will be adversely affected. The pre-feasibility road and quarry plans were not available (and continue to remain tentative) during socio-economic surveys. In these cases, as with transmission line towers, resettlement may involve moving short distances. During feasibility studies, detailed planning should be able to avoid a number, if not many, of these villages and their resources.

Resettlement and compensation is carried out according to the Proclamation No. 455/2005 - A Proclamation to Provide for the Expropriation of Land Holdings for Public Purposes and Payment of Compensation.

Access to available land in the target woredas is not considered a big problem by the regional administration. As presented earlier, as the settlement pattern in the project area woredas is highly dispersed and population density is among the lowest in the region, the regional government has plans for new settlements to which services may be more efficiently provided.

Comprehensive resettlement planning will be required with full consultations of local communities. All necessary facilities should be established for these people so as to lead to a better way of life. A Resettlement Action Plan (RAP) is required. RAP should cover monitoring and management during the construction and operational periods. The RAP requires to be developed by the project and regional government for which federal and external assistance will be required.

6.5.12 Access to Natural Resources

Agriculture practices are supplemented by uses of natural resources in the project area. These mainly include collection of honey, fish and possibly hunting wild animals. These activities are mainly meant for family consumption and generate income in some cases.

All the estimated quantities and values of natural resources used are based on discussions with the communities and woreda staff (Table 6.9).

Table 6.9 : Compensation for Natural Resources

No.	Natural Resource	Unit	Unit Cost ETB	Quantity	Total Cost ETB/YR	Compensation 10 Yrs (ETB)
1	Honey	Kg	10	4,860	48,600	486,000
2	Hunting	No	100	7,182	718,200	7,182,000
3	Fish	No	5	38,880	194,400	1,944,000
Total					961,200	9,612,000

Source: Study team group discussions

Mitigation

Mitigation measures for reduced access to natural resource during the construction phase, and through the operational phase, generally comprise environmental and social enhancement measures. They also include environmental protection measures by the contractor and construction workers to avoid or minimize construction activities that cause adverse impacts such as oil pollution and increased turbidity.

Mitigation measures include:

- Compensation for lost natural resources as per the national proclamation
- Replanting to replace vegetation cover in the surrounding area
- Training of farmers, and professionals in sector offices, in relation to conservation of similar natural vegetation in surrounding areas
- Compensation for the losses as a community gain or individually, as necessary
- Assisting sustainable utilization of the lost resources in neighbouring areas.

6.5.13 Water Supply for Domestic and Other Purposes

Rainfall in the Mandaya dam site and surrounding area extends from June to September (sometimes later) and construction activities during this period may increases turbidity of the Abbay river. Oil and other chemicals from construction machinery and activities may pollute water sources and adversely affect water supplies for human and livestock populations.

Mitigation

Mitigation measures include environmental protection measures by the contractor and construction workers to avoid or minimize construction activities that cause adverse impacts such as oil pollution and increased turbidity (Table 6.1). The contractor’s plan, in response to the Owner’s EMP, should cover avoiding soil erosion and construction activities causing contaminated surface runoff during the rainy season, ensuring proper handling and use of toxic compounds during construction, preventing cleaning of trucks and other vehicles near or in water bodies to avoid chemical contamination, proper siting of construction camps with provision for safe disposal of solid and liquid wastes, and ensure construction of water schemes for the surrounding settlement areas (in association with RAP) to prevent open access to the reservoir during project construction and operation.

6.5.14 Aesthetic Landscape

Aesthetic appreciation, or dismay, at the sight of dams, reservoirs and transmission lines is in the eye of the beholder and little or nothing can be done about this.

However, there are two aspects of the Mandaya project about which something can and should be done. These relate to post-construction rehabilitation and landscaping of works areas and to clearing the reservoir basin to avoid dead trees standing up through the reservoir water surface later.

Mitigation

The project EMP should specify rehabilitation and landscaping of all works areas and clearing the reservoir basin to avoid dead trees standing up through the reservoir water surface later – at least in the reservoir areas upstream of the dam.

6.5.15 Archaeological or Historical Locations

Review of literature and study documents has indicated no sites of archaeological or historical importance in the proposed reservoir and surrounding area and hence no specific mitigation measures are currently proposed. However, it is conceivable that more detailed studies, and/or contractor's works, will reveal artefacts of historical interest.

Mitigation

No mitigation is foreseen on the basis of current scoping. However, provisions should be made firstly for further investigations, and secondly for adequate procedures for protecting/recording and conserving artefacts that may be found during the construction period.

6.5.16 Health Status of Old and New Communities

The present low-level public health status in the project area is related to the limitations of people's knowledge of the causes of health problems and to inadequate health facilities. During the project construction, increased health problems may be expected relating to accidents, use of chemicals, dust, noise, waste disposal, traffic and STDs, HIV, etc. resulting from the influx of construction workers and camp followers. For resettlement communities, upgraded health services are required in new locations.

Mitigation

Mitigation measures include those of the contractor in Table 6.1 (to avoid health problems) and specifically for health education, screening, protection and care as will be required in the contractor's health care plan in response to the project's EMP. These will include:

- Continuous health education to employees, camp followers and local people that are participating in the project construction activities
- Conducting and encouraging tests for diseases, including HIV, for employees, camp followers and local people that are participating in the project construction activities
- Provision of treated mosquito nets to construction employees, camp followers and local people that are participating in the project construction activities
- Ensuring proper sanitation and waste disposal
- Appropriate camp siting.

An estimated cost of ETB 500,000 is allocated for health measures beyond health services provided by the contractor.

6.5.17 Access to Social Services

Availability of social services in the project construction and surrounding areas is very limited. Among others, major social services that require consideration in the project area include health, safe water supply and education. Influx of a large number of workers will create further pressure on the existing facilities such as health services and the contractor must provide these for them in response to requirements of the project's EMP. With respect to public health services, increases in transmittable diseases that include STDs, HIV and other cases is inevitable. Prostitution could be a prime cause of such disease transmissions in the presence of many young construction workers with cash incomes.

Safe water supplies in the project area are absent. Consequently, disease cases relating to the absence of safe water supply are common.

Construction workers usually arrive at sites with their families and increase pressure on existing education facilities. It is likely that some of the local labour force will remain in the project area even after the completion of construction activities.

Thus, resettlement planning should include high standard provisions for all resettled families. Where there are host communities, planning should make provision for improvements for them. Table 6.10 provides a preliminary assessment of required infrastructure for social services for resettlement areas.

Table 6.10 : Proposed Social Services in Resettlement Areas

No.	Type of Social Service	Unit	Unit Cost	Quantity	ETB
1	Health Post	No.	484,119	1	484,119
2	School	No.	480,000	1	480,000
3	Water schemes	No.	108,000	2	216,000
4	Sanitation	HH	120	324	38,880
5	Others	HH	1,537	324	497,988
Total					1,716,987

Mitigation

The contractor must look after (plan, provide, manage, monitor and pay for) health, water supply and sanitation, and any education requirements of construction workers and camp followers, as will be included in the project EMP.

The RAP must make provisions for all resettlers' requirements and host communities where applicable.

6.5.18 Grave Yards

No loss of graveyards is expected due to construction works.

Mitigation

No mitigation measures are currently foreseen. If it is found that they are required, provision should be made in the project EMP.

6.5.19 Social Structure of Existing Communities

There may be changes in social structure due to cultural interaction between construction workers and camp followers and local resettlers and residents in woredas who are not involved with the project. Some changes may be negative but exposure to new influences can also bring better life styles. Residents are already familiar with different types of visitors so no immediate cultural shock is expected.

Mitigation

Changes are considered generally positive. Mitigation is needed with regard to public health awareness and education and health facilities and services.

6.5.20 Employment Opportunities

The project will create temporary and permanent employment opportunities due to construction and other support activities (sale of food and consumables, barbers, shoe makers, etc). Many skilled and semi-skilled workers are expected to arrive from previous construction sites in other regions. When construction finishes, workers will be laid off.

Mitigation

Measures are required to maximize local employment during construction, and for training/apprenticeship courses to be provided to enable this whenever possible. This requirement, for preferential employment of residents of Benishangul Gumuz region where practicable, should be reflected in contractors' tenders and seriously pursued.

6.5.21 Commercial and Trade Opportunities

It is normal for major construction sites, with many workers, to increase trading activities in the area and for local people to supply foodstuffs to the workforce. Also, manufactured goods and fuel need to be imported from elsewhere to the construction site. However, at some development sites, this may give rise to shortages locally and to price inflation, causing local people to suffer as a result of shortages and price increases. Careful consideration will be required to protect the local community whilst not denying them opportunities to increase trading activities.

Mitigation

In project planning, care is needed to establish what foodstuffs may be provided locally from the region without causing local price inflation. This should determine policy on whether food supplies of some or all commodities for the contractor's workforce should be sourced locally (incidentally, with minor carbon footprint) or whether the contractor should be self-sufficient by bringing in foodstuffs from elsewhere.

6.5.22 Energy Use

There is currently no electricity supply in the Mandaya area. It is probable that the contractor will install diesel generators for all electricity requirements during construction. These requirements include electricity for hot water and cooking food for the large workforce. If this is the case, there should be no cutting of trees and shrubs by the contractor or workforce for charcoal or fuel wood.

Mitigation

The project EMP regarding vegetation clearing and construction work camps should make clear what use may be made of local timber, if any (Table 6.1). Depending on the timing and extent of the reservoir clearance program, it is conceivable that the EMP may permit some cleared timber to be used for energy purposes.

6.5.23 Migration

A large number of people are expected to migrate to the project area for employment and trading. Employment levels will change as construction continues, reaching a peak of about 2,000 to 3,000 and falling to say 30 during the operational period. Most workers are expected to leave the area when laid off.

Mitigation

Health, food, water supplies, sanitation and cultural exchanges have been considered earlier. There will be need for contractors and woredas dealing with RAP to make sure that supplies and services will be sufficient for construction workers and camp followers and for resettlement and host communities.

6.5.24 Tourism

There is no tourism in the project area.

6.5.25 Living Standards and Poverty Level

Living standards of employed persons at the construction site may be expected to rise. It is the duty of the RAP to ensure the existing poor conditions of resettlers and host communities is improved.

Mitigation

A comprehensive RAP is required to be professionally prepared, implemented and independently monitored.

6.5.26 Construction impacts downstream of Mandaya in Ethiopia

There are expected to be several potential impacts along the Abbay downstream of the Mandaya construction works areas. Most of these should be avoided or minimized by implementation of the contractor's mitigation measures already described (Table 6.1). There are three particular impacts to which special attention will be required.

River crossings and safety issues

Significant changes in water releases in connection with cofferdam operations and river diversion works are not expected. Normally, discharges downstream will be received "as usual" in the construction period until first filling begins. At this time, there is expected to be changes in seasonal release patterns as prescribed in the Owner's requirements. As mentioned earlier, the determination of the downstream release regime during cofferdam operations and during first-filling of the reservoir (and during operations) requires thorough consideration and agreement with authorities in Ethiopia, Sudan and Egypt.

The agreed release rates incorporated in the Owner's requirements are likely to require increasing and then decreasing downstream flow rates at certain times of the year in order to safeguard riparian interests downstream, particularly irrigation requirements in Sudan.

It is expected that river crossings of Abbay by small boats (felucos) – effectively "ferry" services for people in Sirba Abbay, Guba and Wonbera wordedas and from further a field – will be generally undisturbed by construction activities upstream. However, the potential will exist for rapid changes in water levels, particularly when increasing downstream releases at the dam site.

Mitigation

Precautionary downstream warning measures may be required in advance of changes in releases. These measures should be included in the Owner's requirements.

Recession agriculture

When impoundment begins, and variable downstream releases are made according to an agreed program, flows in the rainy season are likely to be contained within the Abbay channel (and not flow out of bank). During operations, spillway discharges at Mandaya will be infrequent (as described in Chapter 7). In the impoundment and operational periods, the released flows from Mandaya will be joined by local runoff, including natural flood flows of Dabus on the left bank and Beles on the right bank (supplemented by 77 m^3/s transfer from Lake Tana) but the extent and duration of annual overbank flooding of Abbay will be reduced.

The amount of flood recession agriculture in this downstream reach is estimated at 2,400 ha. This area varies from year to year according to natural flooding conditions. With Mandaya's impacts, crop production will be reduced.

Mitigation

Mitigation measures could be in the form of monetary compensation for 10 years loss of production. This is valued at ETB 64.836 million (Border IEA Report, 2007). Alternatively, pumps and pumping energy costs could be supplied for irrigation of the land in place of flooding. This would make possible the irrigation of two crops per year. The cost of pumping has not been assessed for this study and the compensation estimate is therefore carried forward as a Mandaya project cost. In future studies, the pumping option should be fully explored. If viable, this could not only produce a crop instead of flood recession but another crop each year also.

Gold panning

Gold panning in this reach would be affected in three ways by Mandaya reservoir impoundment.

1) contributing sources to the alluvial gold along the Abbay river channel are considered to be many. Whatever amounts are contributed to the lower reaches of Abbay after the river leaves Mandaya Gorge will permanently stop when impoundment begins at Mandaya. The quantities are unknown and unknowable.

2) the time for gold panning may be extended when Mandaya is first-filling. This will depend on the variable downstream releases during first filling according to the agreed program. This may give opportunities, though not designed for this purpose, for a longer period of gold panning.

3) when Mandaya becomes operational, and dry season flows are significantly raised, opportunities for gold panning in the main Abbay channel will probably effectively cease.

In all of these cases, gold panning can continue in tributaries more or less as before.

Mitigation

Compensation to the affected communities should be paid for lost natural resources. This issue requires greater consultations during feasibility studies. For current purposes, compensation of ETB 21.6 million over 10 years is made as a Mandaya project cost. This is 10% of the 10-year compensation included in the Border IEA report (2007).

Downstream construction impacts in Sudan and Egypt are considered in Section 6.6.

6.5.27 Public Relations, Communications and Grievances

When major dams are constructed, creating large reservoirs with the need for a resettlement program, and causing a large workforce to concentrate in camps, there are limitless opportunities for grievances to occur. Whilst the contractors will take responsibility for their workforce and establish a grievance procedure, there is need to establish good public relations between the project owners and the local communities, regional government and other agencies. This requires transparency about the project, its impacts and mitigation measures, including grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement but also to many other stakeholders. Care has to be taken to present information in languages that are understood by stakeholders, and by all conceivable means in order to reach all concerned effectively.

Among the earliest common grievances are those relating to acquisition of land (how much?, where? and when?) for the project construction activities.

Further studies will be required to define the project more closely so that EIA and RAP reports may be as precise as possible. These are then typically followed by revisions to engineering design before and even after construction begins. Some 2,000 or 3,000 or more engineering drawings will be produced during final design; some will be amended long after final EIA and RAP reports are produced and made public. Only perhaps two or three project staff may know these amendments, some of which may have a direct bearing on the extent and magnitude of impacts. These may or may not be significant. The point is made that opportunities for misinformation and misunderstanding are many during the construction period and every effort has to be made to avoid these by establishing a first class public relations and communications system, and then using it vigorously.

The public is also keenly interested in dam safety. In Mandaya's case, this means people downstream of the dam in Ethiopia and in Sudan and Egypt.

Mitigation

The project will need to develop a first class public relations and communications system for all aspects of the project, including grievance procedures and dam safety related matters.

6.5.28 Dam and Public Safety

RCC dams are considered by many to be the safest types of dams. However, the consequences of dam failure, failure of other structures and mechanical equipment or mal operation (e.g. spillway gates) and failure of warning systems could be catastrophic, not only for the Mandaya project itself but also at all places along the Blue Nile downstream including Roseires, Sennar, and Khartoum and along the Main Nile (Section 6.6.15). This is one of the reasons that owners of a new major dam employ an independent Panel of Experts (POE) to review design and design changes and inspect the construction works closely. The POE also, importantly, reviews the engineering operation and maintenance plans for the project and insists on failsafe systems being adopted. The POE also includes in its brief oversight of hazards plans including those for flood forecasting and flood warning.

Mitigation

A dam safety Panel of Experts is required, and for its findings to be made known to the public at all times.

Because of the overwhelming international importance of the dam safety issue at Mandaya, Section 6.6.15 (covering this issue for Sudan and Egypt) expands on this by describing the anticipated probable scope of work of the POE for dam safety procedures.

6.5.29 Environmental and Community Protection

It is believed that the magnitude and extent of environmental and social impacts that have been considered in this report are large and serious enough to require the Owner to appoint an independent Panel of Experts for the Environment and Community Protection. The composition of this panel is a matter for the future but this report indicates that special expertise in vegetation and vegetation clearance, wildlife habitat and environmental offset planning and management, resettlement and irrigation will be required as a minimum. It is noted that the expert in vegetation and vegetation clearance would not only cover works areas and reservoir basin clearance but also the many new access roads. Consideration should be given to appointing a female specialist for work on resettlement, as half the host and resettled communities are female and many are Muslim.

Mitigation

An Environmental and Community Protection Panel of Experts is required, and for its findings to be made known to the public at all times.

6.6 CONSTRUCTION AND IMPOUNDMENT IMPACTS IN SUDAN AND EGYPT

6.6.1 Introduction

The assumption is made here that the future planning stages of this project will continue to fully involve Ethiopia, Sudan and Egypt, as occurring through NBI, ENTRO and in this pre-feasibility study. The logical sequence of this is that all parties will have contributed to planning, and agreement will have been reached on the downstream release requirements and downstream mitigation measures.

6.6.2 Water Resources and Energy Impacts

The physical impacts and timing of cofferdam works and reservoir first filling are described in Section 6.2 and Table 6.2.

The determination of the downstream release regime during cofferdam operations and during first-filling of the reservoir (and during operations) requires thorough consideration and agreement with authorities in Ethiopia, Sudan and Egypt. The agreed release rates will be incorporated in the Owner's requirements.

With regard to impacts of the first filling of Mandaya on High Aswan Dam, it is clear, other things being equal, that Lake Nasser/Nubia storage contents will be reduced by 24.6 billion m^3 when Mandaya is filled to MOL, and by 49.2 billion m^3 when Mandaya is filled to FSL. This is an inescapable fact when filling a reservoir upstream of an existing reservoir and assuming the storage contents of the lower reservoir are not at a level to cause it to spill. The likelihood of Lake Nasser/Nubia being in a spill condition is so remote that it may be discounted for current purposes.

Five simulations have been performed to investigate the range of time required for filling Mandaya reservoir. These start at 10-year intervals through the hydrological record (Table 6.11).

Table 6.11 : Months for Mandaya Filling to Minimum Operation and Full Supply Levels

Filling Start (January)	Months to Minimum Operation Level (EL. 760 m)	Months to Full Supply Level (El. 800 m)
1954	10	22
1964	10	70
1974	19	58
1984	23	58
1994	9	56
Average	14.2	52.8

Source: Pre-feasibility Engineering Report

The 1984 hydrological year is the driest in the 50-year record and so a sequence starting in that year was used to establish by-pass flows during the first year of Mandaya filling (whilst below minimum generation level). The objective adopted was to ensure that Roseires reservoir could always be filled as usual at the end of the flood season. This was just achieved with Mandaya first-year bypass monthly flows set to 250 percent of the environmental releases that had been defined previously (presented later as prescribed minimum flows at Mandaya in Table 7.6), but capped at the assumed 1,000 m^3/s bypass capacity. These same flows were retained for the first year of each of the other five filling simulations.

Results of these five simulations in terms of base-case and filling-simulation energy outputs are presented in the Pre-feasibility engineering report.

In all cases, the impact of filling Mandaya reservoir would be to reduce the volume of water stored in Aswan by a similar amount over the filling period compared to the level that would otherwise occur. Assuming that Lake Nasser/Nubia was at a level of 175 masl at the start of filling of Mandaya, the volume would reduce from 121.3 billion m^3 to some 72.1 billion m^3. The corresponding reduction in water level would be from 175 masl to 163.2 masl, a drop of 11.8 metres, although the exact amount would depend on the hydrology over the Mandaya filling period (e.g. a fall of 7 metres was indicated for first filling beginning with 1954 hydrology, and 18 metres for first filling beginning with 1984 hydrology). This reduction in level would reduce the head for energy generation at Aswan accordingly. In all cases of simulations, releases made at Mandaya were sufficient to meet water demands in Egypt for the criteria adopted in RAPSO simulation runs but clearly this requires further elaboration in future studies.

The over-riding and important point is that simulations demonstrate that Mandaya can be filled without jeopardising water supplies downstream. As noted, the duration of filling to MOL when turbines can be tested and some generation can begin may be as short as nine or 10 months or as long as two years. The duration of filling to FSL may be as short as two years or as long as six years. These durations are derived for the five runs; durations could be shorter or longer for other filling sequences according to the sequence of hydrology.

They could also be shorter or longer according to the adopted prescribed minimum releases at Mandaya during first filling. This raises an important point. If future studies demonstrate that smaller releases during first filling would meet Sudan’s water demands (though Sudan’s and Aswan’s energy generation would be lower) and speed up Mandaya’s first filling (for the benefit of project finances and all countries benefiting from Mandaya’s earlier full generation and concomitant flow regulation) and Lake Nasser/Nubia’s storage contents threatened to become unsatisfactorily low for Egypt’s water supplies, the opportunity will always exist to release Mandaya’s stored water as early regulation releases to satisfy Egypt’s water supply demands and prevent the impending shortfall. Mandaya’s stored water, being upstream, is not lost to the system but always available for release.

Impacts on energy generation in Sudan and High Aswan Dam are presented in the Pre-feasibility Engineering Report for the five simulation runs individually for the first four years of filling at Mandaya. The average outputs of the five runs are presented in Table 6.12. The average energy “losses” of these runs, in the bottom row, are losses compared to the base case where Mandaya is fully operational. The average losses are some 19 and 18% in the first two years, reducing to 3 and 2% in the third and fourth years. Average figures necessarily disguise behaviour in individual sequences but provide a useful summary of the trend towards full production.

Table 6.12 : Average Effects of Mandaya Filling on Energy Outputs (GWh/year) for filling sequences beginning in 1954, 1964, 1974, 1984 and 1994

	1st year		2nd year		3rd year		4th year	
Hydropower station	**Base**	**Filling**	**Base**	**Filling**	**Base**	**Filling**	**Base**	**Filling**
Mandaya	12,309	2,116	11,210	5,773	12,267	10,289	12,136	11,521
Roseires	2,131	1,406	2,046	1,366	2,153	2,009	2,147	2,120
Sennar	484	306	469	284	491	459	494	495
Jebel Auilia	122	117	138	151	141	145	139	141
Kashm el Girba	34	34	35	35	37	37	34	34
Merowe	6,291	4,870	6,554	5,106	6,356	5,967	5,924	5,830
Subtotal Sudan	9,062	6,733	9,242	6,941	9,178	8,619	8,739	8,620
Sudan loss	2,329	25.7%	2,301	24.9%	559	6.1%	119	1.4%
High Aswan	7,703	6,798	7,595	6,806	6,799	6,798	6,634	6,395
Sudan + High Aswan	16,765	13,531	16,837	13,747	15,977	15,417	15,373	15,015
Loss	3,234	19.3%	3,090	18.4%	560	3.5%	358	2.3%

Source: Pre-feasibility Engineering Report

Mitigation

The determination of the downstream release regime during cofferdam operations and during first-filling of Mandaya reservoir (and during operations) requires thorough consideration and agreement with authorities in Ethiopia, Sudan and Egypt. The project owner will present the finally agreed downstream release pattern to the construction contractor for implementation.

The assumption is made here, as it is throughout this initial environmental assessment, that this multipurpose international project will avoid creating adverse impacts wherever practicable, and minimise and compensate for unavoidable adverse impacts.

Thus, in practice, several sets of downstream release regimes (or formulae for calculating downstream release regimes) may be developed, all being agreed by Ethiopia, Sudan and Egypt. This agreed flexibility would provide agreed contingency plans for hydrological conditions pertaining during first filling.

For example, in the event of the preferred agreed downstream release regime being unsatisfactory in practice, say after the first or second year of first filling and not satisfying vital downstream water supply security criteria (e.g. not meeting prescribed minimum target storage levels in Lake Nasser/Nubia to protect Egypt's water supplies in the following six or twelve months), agreed contingency plans might need to be implemented. This might occur if a sequence of severe drought years develops (such as experienced in the mid 1980s, or perhaps a sequence even more severe) and threatens to continue and jeopardise irrigated food and water supplies for millions of people in Egypt. In such a case, greater releases would be made from Mandaya and the delay in completing first filling and bringing on full power generation at Mandaya would necessarily have to be accepted by all. It is presumed that this sort of hydrological risk will need to be accepted and borne by the project owner. If it is not so, it is difficult to envisage the Mandaya project, with the large storage capacity proposed in this pre-feasibility study, proceeding.

In all of these very serious considerations, it needs to be always recalled that "Mandaya's stored water, being upstream, is not lost to the system but always available for release". Time of travel studies have not been conducted for this assessment but it is expected that these will demonstrate that increased releases from Mandaya, should they be needed in a contingency plan, would enter Lake Nasser/Nubia within three or four weeks. This is important. Although the reaction time is not instant and requires good planning and communication and monitoring systems, the time is more than sufficient to make good an impending shortfall. There should be no reason whatsoever for downstream users (irrigation and water supply) along the Nile in Sudan or downstream of Aswan to suffer water supply shortages, either during first filling or afterwards.

More studies of Aswan will be required in future feasibility studies. There is need for specific studies of Aswan operations in relation to the sequence of construction and filling of all the potential reservoirs (Karadobi, Beko Abo, Mandaya and Border).

There are some other first filling issues relating to riparian users of Lake Nasser/Nubia. These are discussed in subsequent sections of this chapter.

6.6.3 Water Quality Impacts

There is insufficient data available on Abbay water quality, soils and residual biomass in the Mandaya reservoir area to assess impacts on water quality from the time of first filling.

Mitigation

A water quality simulation model will be required to assess seasonal changes in reservoir water quality and project design and management strategies to minimize adverse changes. For this model, data from future water quality sampling, soil sampling and biomass studies will be required.

6.6.4 Sedimentation Impacts

Reservoir sedimentation will begin when first filling begins in the construction period and continue throughout the life of the project.

Sediment loads will be significantly reduced downstream, notwithstanding some entrainment of sediment from channel adjustments which may take place owing to Mandaya releases having more capacity to erode channels and transport sediment, and to the release pattern itself.

Substantial benefits will result from reduction in sediment loads from the time of first filling. The main benefits are expected as follows:

- Conserving storage capacity and yield at Roseires, Sennar, Merowe and High Aswan Dam

- Reduced dredging costs at Roseires
- Improved power generation at Roseires, Sennar and Merowe
- Reduced siltation clearance costs at pumping stations
- Reduced silt clearance costs in irrigation canals

The full benefits of these, and others, will be felt in the operation period. These are considered further in Chapter 7.

From first filling, the reduction in downstream sediment loads will reduce the annual dressing of silt given to cultivated alluvial areas (as a free fertilizer) along the Blue Nile and along the Main Nile during the annual flood.

Mitigation

With regard to mitigation for reductions in valued silt deposits downstream, as has occurred on the Main Nile in Egypt following construction of High Aswan Dam, use of artificial fertilizers is expected. This aspect is necessarily linked to reductions in flood magnitude, duration and frequency. Much greater study is required of this subject area before the feasibility, acceptability and cost of this can be assessed.

With regard to changes in river channel morphology, resulting from reduced sediment loads in turbine and spillway releases at Mandaya, there may be need for river training works, bank protection and other measures. Much greater study is required of this before the potential needs can be assessed. A specific department or section may require to be established, with a budget for this purpose, as has occurred in Egypt because of river morphology adjustments below High Aswan Dam.

6.6.5 Impacts on Minerals

On first impoundment in the construction period, Mandaya reservoir will inundate an area of 736 km^2 including a long length of the Abbay river channel and a shorter length of the Didessa. Any alluvial gold conveyed through the Mandaya site will therefore be trapped upstream, and this portion of the renewable resource will be lost to the people living in adjacent areas and downstream as far as Roseires reservoir. It is assumed that Roseires is the downstream limit of this impact because Roseires dam itself will have had the same impact.

However, if Roseires dam is raised to a higher level before Mandaya (or Border) is constructed, thereby impounding this river reach, the loss of gold panning opportunities here will be ascribable to the Roseires project and not to the Ethiopian storage development later.

Mitigation

Compensation may be required for any communities engaged in gold panning along the Blue Nile in Sudan between El Deim and Roseires, as described for the lower Abbay above. This needs to be addressed in future studies.

6.6.6 Trash Loads

During first filling, loose residual woody material, and other floating materials, will cover parts of the reservoir. None of this material can escape from the reservoir until such time as the spillway operates, when water currents and winds may direct materials to the dam, power station intake and spillway. Booms will control and divert floating materials and trash racks will remove materials at the Mandaya intake. Trees, shrubs, dead animals and other materials that pass through the spillway will eventually be received in Roseires reservoir. This cycle then repeats itself at Roseires, Sennar and Merowe dams and at any other existing (or future) structures/intakes downstream.

Potentially, such quantities of floating and semi-submerged materials (in addition to the normal trash load carried by the Abbay and tributaries) could be troublesome at Mandaya dam and at structures in Sudan downstream.

Mitigation

Mandaya reservoir basin clearance needs to be effective. This aspect relating to dealing with additional trash at Mandaya, and at Sudan's river structures, from Mandaya's reservoir basin clearance and first impoundment, requires to be fully considered in future studies with mitigation measures being included in the EMP concerning reservoir basin clearance.

6.6.7 Aquatic Fauna

When the upstream cofferdam is constructed, an area of river channel, riverbanks and adjacent land will be flooded. Flows will be diverted, to permit dam site construction works, and be released in the Abbay channel downstream of the downstream cofferdam. Changes in aquatic life are expected during this time as the habitat changes from a running river to lacustrine environment. Impacts in Sudan may be negligible and insignificant.

During the first impoundment of Mandaya reservoir, major changes may be expected to begin and continue until species suited to a reservoir aquatic environment are established.

Although there is not yet clarity about which of the 29 fish species in the Blue Nile (Mishrigi, 1970) migrate from the Blue Nile and Roseires reservoir to the Abbay, Beles and Dabus and to smaller tributaries for spawning (i.e. through the Mandaya reservoir reach), it is clear that the Mandaya dam project will stop such natural upstream migrations.

According to information available from FAO (2001), Roseires reservoir has a potential of 1,700 tons/year and fish landings of 1,500 tons/year (88%) from a surface area of 290 km^2. 22 fish species, 1,200 fishermen and 550 boats are reported to be involved.

It is therefore not clear which fish species, if any, in Roseires reservoir depend on upstream migration through the Mandaya dam site as part of their life cycle. Impacts on Roseires fisheries and dependent livelihoods cannot therefore be assessed.

During first filling of Mandaya, the Nile's normal annual flood and its normal sediment load will not arrive at Lake Nasser/Nubia. By storing water in Mandaya during first filling, the water stored upstream cannot sustain Lake Nasser/Nubia levels as before and a fall in lake level by some 7 or 12 or 18 m has been indicated. Thus, during first filling of Mandaya, a smaller lake surface area and reduced sediment loads will occur at Lake Nasser/Nubia. Compared to a level of 175 masl, with surface area of about 5,168 km^2, a fall of 12 m to 163 masl would imply a lake area of some 3,330 km^2, an area reduction of 1,840 km^2. In terms of primary production, reduced sediment loads imply greater light penetration and probably greater primary production and greater food sources for some fish species.

Another impact relates to the reduction in the Nile's annual flood. It is considered that the annual flood triggers spawning of some fish species in the Nubian parts of the lake. This presumed stimulus for fish spawning of some species will be reduced to that provided by the annual floodwater of Dabus, Beles, Rahad, Dinder and Atbara rivers.

Lake Nasser/Nubia has experienced lower levels than 163 masl in the past. These occurred in the first 10 years of first filling, and again in the drought of the mid 1980s. The first 10 years of low levels during first filling were associated with increasing fish catches while the drought years of the mid 1980s had annual catches of 24,000 and 26,000 tons in 1984 and 1985, followed by about 16,000 tons in the succeeding two dry years and in the flood year of 1988 (Table 5.17). These production figures alone are not in themselves helpful in assessing the lake's fisheries productivity in terms of lake level because there are many factors to be considered, including reported fishing effort at the time, smuggling and previous stocking rates with fingerlings, etc. Thus a recurrence of lower levels caused by Mandaya's first filling would not necessarily be associated with the same production as occurred before, there being no clear relationship between lake level and production.

Mitigation

This report identifies an inadequate but improving aquatic database for Abbay at Mandaya but a potentially rich source of knowledge at Roseires in Sudan. Further surveys and studies will be needed to assess impacts in the construction (and first filling period) and operational phases. These aquatic surveys may be expected to improve knowledge of fish species, migrations and other characteristics but also contribute to development of a policy for clearing of woody biomass in Mandaya reservoir prior to first filling – in particular, with regard to substrates useful for aquatic life, areas where stumps should, or should not be cleared, or be only partially cleared.

Environmental management and monitoring plans for aquatic life and fisheries development will be required following future water quality and aquatic surveys extending from Roseires to upstream of Mandaya reservoir, and following results of water quality modelling and review of Roseires' database. These aquatic surveys are expected to take at least two years.

For Lake Nasser/Nubia's aquatic fauna and flora, detailed studies will be needed to assess impacts of Mandaya in the first filling period (and operational phase) and relate these to the existing uses and proposals for additional fisheries development of the lake. These studies may be inconclusive but indicate that some mitigation measures, or contingency mitigation measures, may be required such as additional stocking and, in the worst case scenario, provision of support and food supplies for the fishing community. This aspect is considered further in Section 6.6.13.

6.6.8 Transmission Line Routing and Wildlife Habitat

The project's transmission lines have been discussed in Section 6.5.5 as a whole where comments on the route from Mandaya to Hasaheisa or to Rabak are included. For the purposes of including impacts during construction in Sudan in this section, the position is summarised as follows.

The route from Mandaya to Hasaheisa/Rabak has not been visited for this study. Available land use mapping and satellite imagery indicate that open woodland and shrubland continues northwards from Mandaya past Roseires reservoir to Damazin until some rainfed cropping occurs intermittently with shrubland before passing through irrigated land. Tower construction and road or track access for construction and line maintenance may be expected to be difficult in the wet season in black cotton soils which are the dominant soil type. Towards Hasaheisa, land use is very intensive. In order to minimise disturbance, it is preferred that the final section of the interconnecting route should be to Rabak.

Roseires dam has not been raised. Work on this started but was subsequently curtailed. It is now understood that Roseires will be raised in the near future and it is noted therefore that future detailed studies of the Mandaya transmission line to Sudan will need to ensure routing avoids the higher full supply level and any raised groundwater impacts of Roseires reservoir.

Mitigation

Generally, the loss of cropping along the route will not be permanent, excepting for the very small cumulative area occupied by towers. Crops may be lost for one year, perhaps two at most, owing to clearing of the 1 x 40 m right of way (ROW) and stringing the conductors. Cultivation of land and income from crops is expected to be restored following these activities. Compensation estimates for transmission lines from Mandaya switchyard to Sudan are given in Table 6.7.

Detailed surveys are required including bird habitats, raptors, water birds and flyways. Bird diverters may be required on the conductors if the selected route cannot avoid areas of high flyway use.

The recent Ethiopia/Sudan Interconnection EIA and RAP reports (SMEC, 2006) have provided a template for future detailed studies which are generally applicable to this transmission line, including monitoring and management arrangements. An EMP and RAP will be required for the Mandaya to Sudan transmission line.

6.6.9 Irrigation

During first-filling of Mandaya reservoir, there is potential for water shortages to be created at existing irrigation schemes in Sudan and Egypt.

In addition to making provision for water supplies to existing irrigation schemes in Sudan during first filling, there will be need to mitigate other farmers and communities along the Blue and Main Nile for loss of the bulk of the annual flood. This is not only a first filling impact but continues throughout the operational period. It is discussed in detail in Chapter 7.

Mandaya's first filling, which may cause Lake Nasser/Nubia water levels to drop by some 7, 12 or 18 m, will have an impact on settlement schemes and farmers cultivating around Lake Nasser/Nubia's shoreline and cultivating within the lake's drawdown zone. Some 1,000 people in 314 groups (Table 5.13, Figure 5.27) are involved. It is anticipated that some of the communities using pumps will need to pump water through greater lifts, thereby increasing their operating costs.

Mubarak pumping station and Sheik Zayed Canal (Figure 5.28) are constructed but reported to be not operating. If this very large Toshka irrigation scheme becomes operational before Mandaya's first filling, operational costs for pumping through greater lifts may be expected to increase significantly.

Mitigation

As mentioned earlier, a fully developed and agreed programme for reservoir first filling is required including prescribed releases to meet downstream irrigation demands (and energy generation) in Sudan and Egypt.

There will be need for large areas in Sudan benefiting from Nile flood recession agriculture to be converted to pumped irrigation before first filling of Mandaya begins. This is a very major undertaking requiring detailed studies (Chapter 7). Failure to provide mitigation could result in hunger and increased poverty on an unprecedented scale, and provision of a major program of emergency food supplies.

Settlement schemes and farmers cultivating around Lake Nasser/Nubia's shoreline and cultivating within the lake's drawdown zone will require a range of assistance measures, including financial assistance to cover additional irrigation costs. This is an undertaking requiring detailed studies. Failure to provide mitigation could result in hunger and increased poverty, and provision of a program of emergency food supplies.

If the Toshka irrigation scheme becomes operational before Mandaya's first filling, compensation for increased operating costs for pumping through greater lifts will be required.

6.6.10 Resettlement

A Resettlement Action Plan (RAP) is expected to be required to cover the construction of the transmission line to Sudan with sequential movements of resettlers before construction. RAP should also cover monitoring and management during the operational period. Compensation and any resettlement associated with upgrading of existing transmission lines and associated works in Sudan, and for a transmission line from Sudan to Egypt will require full assessment in subsequent studies. However, in general terms, most of these works are along routes in a desert environment and only minor resettlement, if any, may be expected.

6.6.11 Rural Development and Electricity Supplies

Some points mentioned in the recent Ethiopia/Sudan Interconnection EIA and RAP reports (SMEC, 2006) are relevant to this project's power lines in Ethiopia and Sudan. One of greatest concerns of the Consultant was how to achieve local support for construction of transmission lines when no local project benefits in the form of local electrification can be demonstrated. It was considered that providing local electricity to PAPs (either directly through the financing of local distribution lines, or indirectly, by reinvesting a proportion of the economic benefits of the project into rural electrification), the project would enhance overall poverty reduction and rural development efforts in the two affected countries.

Electricity supplied to rural towns would replace/reduce the consumption of woody biomass and petroleum products used for cooking, lighting, and motive power. It would support development in the agricultural sector (irrigation pumps, poultry, animal husbandry, preservation of products); in the commercial sector (shops, bars, and restaurants); to small and medium industries (flour mills, rural water supply installations, tanneries, and coffee processing plants), to the residential sector (lighting, heating, and cooking), to education (kindergarten, elementary schools, junior secondary schools, secondary schools and technical colleges), and to the health sector (pharmacies, clinics, health centres and hospitals). In brief, SMEC considered the project would assist in the facilitation of economic growth in project affected areas and create long-term employment opportunities for the poor, including women, thereby increasing income levels and reducing poverty.

Neither SMEC nor we have studied or estimated costs of provision of rural electrification as a development activity along the routes of the interconnecting transmission lines. This is an area for further consideration in future.

6.6.12 Navigation on Lake Nasser/Nubia

Mandaya's first filling, depending on inflow sequences at the time, may cause Lake Nasser/Nubia water levels to drop by some 7, 12 or 18 m. Compared to a level of 175 masl, with surface area of about 5,168 km^2, a fall of 12 m to 163 masl would imply a lake area of some 3,330 km^2, an area reduction of 1,840 km^2. Whilst the lake will remain navigable, this means that difficulties may arise with regard to boat moorings, jetties and pontoon arrangements which would otherwise not occur. Without measures to alleviate these problems, ferry services and other commercial activities that are dependent on functioning shoreline embarking/disembarking facilities may be adversely affected. As with farming and fisheries, and their settlements, in this harsh desert environment, any interruption to communications and freighting produce across the lake may be expected to have significant impacts on the local economy and everybody residing in the area.

It is also noted that a significant fall in lake level can be expected in future, as occurred in the mid 1980s, without first filling of one or more reservoirs in Ethiopia. The experience of low levels in the 1980s needs to be brought together in future studies in order to prepare a plan for low levels in future.

Mitigation

Detailed studies are needed to assess impacts on Lake Nasser/Nubia's navigation physical facilities and operations in the light of Mandaya's first filling period (and operational phase). These studies should reveal the mitigation measures which will definitely be required and those which may be required. The latter would need to be ready for implementation as a contingency plan.

6.6.13 Employment Opportunities and Economy

Construction of the project transmission lines will create temporary employment opportunities. When construction finishes, temporary workers will be laid off.

With regard to the anticipated fall in Lake Nasser/Nubia water levels during Mandaya's first filling, it was noted earlier that impacts may be expected on fisheries in the lake. Some 5,000 fishermen in fishermen's associations, using around 1,600/1,700 boats, and some private sector companies are engaged in fisheries for their livelihoods. The fishermen's associations and private sector companies may experience greater conflict when allocated fishing zones shrink. Those engaged in fish processing and marketing may experience knock-on effects if production is reduced. Employment opportunities in the fisheries sector may therefore temporarily reduce.

Because of the anticipated fall in Lake Nasser/Nubia water levels during Mandaya's first filling, impacts may be expected on settlements and some 1,000 cultivators around the lake, in particular greater pumping costs. Without mitigation measures, these cultivators may be seriously disadvantaged and become unemployed or underemployed.

Similarly, without mitigation measures, any disruption of communications across the lake will adversely impact on employment, the local economy and livelihoods.

Mitigation

Measures are required to maximize local employment during transmission line construction, and for training/apprenticeship courses to be provided to enable this whenever possible.

Mitigation measures, and environmental management and monitoring plans, are required for fisheries, agriculture and navigation relating to Lake Nasser/Nubia. These plans should seek to ensure that those employed in these industries, and their family dependents, are not harmed by reduced lake levels caused by first filling of Mandaya. Proposed mitigation measures, including any monetary compensation, should be discussed with the various communities; they should be acceptable to those concerned and implemented in a timely manner.

It is noted that low lake levels may occur again naturally, as in the mid-1980s. There are three points to be made about this. The first point is that adverse impacts caused by a project in Ethiopia require to be assessed and mitigated by the project, as described above. The physical mitigation measures provided may, subject to durability, be helpful in the event of low levels thereafter.

The second point is that if one or more Ethiopian regulatory storage projects are deferred for many years, any occurrence of low levels in Lake Nasser/Nubia before the Ethiopian storage projects will provide good opportunities to monitor impacts on fisheries, agriculture, navigation and settlements, and the mitigation measures taken – and those not taken but which were required or desirable. This should alert the various communities and research agencies to the need for monitoring not only for the sake of monitoring for their immediate purposes but for its application to improved planning of mitigation measures for one or more Ethiopian regulatory storage projects in future.

The third point is that it is conceivable that levels lower than occurred in the mid-1980s may occur at the time of first filling in Ethiopia. This would not only impact on the local Lake Nasser/Nubia economy and communities but, as in the mid-1980s, on the lifeline of all of Egypt – the regulated Nile. This is one of the reasons why an earlier section has emphasised the point that the agreed prescribed downstream release regime during first filling in Ethiopia (and for releases in the operational period) will require agreed variants of it which may be reverted to in a developing emergency. It is stated again that there must be confidence in Egypt that greater releases of stored water will be made in Ethiopia if target end-of-month storage levels (to protect downstream supplies) in Lake Nasser/Nubia are not met.

"Mandaya's stored water, being upstream, is not lost to the Nile system but always available for release". This sentence, or one framed like it, may require to be embedded in ENTRO's and everyone's thinking in order to overcome this worrying feature for Egypt. If then project construction is begun, and a very severely dry hydrological sequence occurs which forces greater downstream releases to occur to satisfy water supply demands in Egypt, first filling will be slower and full generation will be delayed. This is an inescapable reality and risk. This risk will need to be accepted by the project Owner and lending agencies.

6.6.14 Public Relations, Communications and Grievances

When major dams and transmission lines are constructed, there are limitless opportunities for grievances to occur. Whilst the contractors will take responsibility for their workforce and establish a grievance procedure, there is need to establish good public relations between the project owners and the local communities, regional government and other agencies. This requires transparency about the project, its impacts and mitigation measures, including grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement but also to many other stakeholders. Care has to be taken to present information in languages that are understood by stakeholders, and by all conceivable means in order to reach all concerned effectively.

Among the earliest common grievances are those relating to acquisition of land – how much? where? and when? In Sudan, this applies to the transmission lines, and may apply to mitigation measures relating to river morphology changes and converting flood recession agriculture to pumped irrigation. In Egypt, this also applies to the transmission line and may apply to mitigation measures relating to lowering Lake Nasser/Nubia. (See Appendix 6.2 for notes on compensation procedures in Sudan and Egypt).

Further studies will be required to define the project more closely so that EIA and RAP reports may be as precise as possible. The point is made that opportunities for misinformation and misunderstanding are many during the construction period and every effort has to be made to avoid these by establishing a first class public relations and communications system, and then using it vigorously. The principal construction impacts are mentioned in this section but the public in Sudan making use of the Blue Nile and Main Nile, and the public in Egypt around Lake Nasser/Nubia and benefiting from High Aswan Dam will be keenly interested in not only how construction activities will affect them but especially the operational impacts.

The public is also keenly interested in dam safety. In Mandaya's case, this means people downstream of the dam in Ethiopia and especially in Sudan and Egypt.

Mitigation

The project will need to develop a first class public relations and communications system for all aspects of the project, including grievance procedures and dam safety related matters. Information needs to be communicated in Ethiopia, Sudan and Egypt and care taken that it reaches all relevant stakeholders effectively.

6.6.15 Dam and Public Safety

RCC dams are considered by many to be the safest types of dams. However, the consequences of dam failure, failure of other structures and mechanical equipment or mal operation (e.g. spillway gates) and failure of warning systems could be catastrophic, not only for the Mandaya project itself but also at all places along the Blue Nile downstream including Roseires, Sennar, and Khartoum and along the Main Nile. It is for this reason that owners of new major dams employ an independent Panel of Experts to review design and design changes and inspect the construction works closely. The POE also, importantly, reviews the engineering operation and maintenance plans for the project and insists on failsafe systems being adopted. The POE also includes in its brief oversight of hazards plans including those for flood forecasting and flood warning.

Mitigation

A dam safety Panel of Experts is required, and for its findings to be made known to the public at all times.

Because of the overwhelming international importance of the dam safety issue at Mandaya, the opportunity is taken here to build up confidence and trust of stakeholders in modern dam safety procedures by anticipating the probable scope of work of the POE.

The detailed scope of work for the POE may be expected to include all aspects of dam safety and can be summarised as follows:

- Flood Hydrology: extent and sufficiency of data, methodology for derivation of extreme and design floods, procedures for routing floods throughout the reservoir and impact of floods downstream of the Mandaya power plant;

- Seismology: identification of sources of seismic activity, assignment of earthquake magnitudes to each source, and methodology for derivation of vibration parameters at the site for maximum credible and design basis earthquakes;

- Engineering Geology: quality and sufficiency of the geological investigations and the interpretation thereof; correctness of the geological and hydrological models of the region, reservoir area and dam site; engineering implications with respect to foundation design, stability of natural and excavated slopes; and support of surface excavations;

- Rock Mechanics: design of surface excavations, including selection of stable slopes; design of temporary and permanent support systems and linings;

- Dam Design: adequacy of field and laboratory investigations in relation to materials for construction of the dam and cofferdams, appropriateness of materials selected, proportioning and composition of the various zones, static and dynamic analyses of the dam section; selection of foundation levels, proposed measures of forming cutoffs in and drainage of the foundations and abutments; construction procedures specified in relation to the dam and its foundations, instrumentation of the dam and proposed monitoring programme;

- Hydraulic Design: hydraulic design and specifications of the spillway and energy dissipation facilities, diversion, power conduit and drawdown facilities and tailrace facilities;

- Planning and Design of Dams and Hydropower Facilities: overall layout of the Project; design criteria; specifications; design of hydraulic structures; diversion scheme and sizing of its various components; capacity of the spillway and drawdown tailrace facilities; procedures for routine inspection of the dam and checking safety of structures, including the organisation and staffing of the inspection agency.

- Construction of Dams and Hydropower Facilities: Construction planning studies, temporary facilities, access to the site, master schedule for implementation, conditions of contract, contactors proposals in relation to construction procedures, schedule, river diversion; organisation, staffing and procedures for managing the construction of the Project, methodology and organisation for quality control of the construction;

- Concrete Technology; Adequacy of testing of concrete materials, and their suitability for use in the works, specifications for concrete, mix design and quality control procedures; and

- Specifications and manufacturers' proposals: for turbines, generators and mechanical and electrical equipment in the power station and switchyard, with particular emphasis on design provisions for turbines operating in sediment laden water, and state of the art design of generators, switchgear and control systems.

Thus, the Mandaya project would be developed and constructed according to the highest safety standards, “designing out” the possibility of catastrophic failure. The POE would be provided with the role and authority to scrutinize and ensure that the project implements the requirements of the World Bank’s Dam Safety Policy relating to safety issues in respect of the design, construction, commissioning and operation and maintenance of the project and downstream areas.

7. OPERATIONAL IMPACTS AND MITIGATION MEASURES

This chapter considers impacts and mitigation measures from the time of reservoir first filling.

Section 7.1 describes the overall situation expected in the Mandaya area at the beginning of the operations phase.

Section 7.2 introduces the principal hydrological impacts of the operation of Mandaya reservoir, and the alteration of downstream flows. These are the fundamental primary operational impacts of the project, following construction. Other impacts flow from these.

Sections 7.3 and 7.4 consider principal impacts on the bio-physical and socio-economic environment in the Mandaya region respectively – the direct impact zone.

Section 7.5 summarises operational phase impacts downstream of Mandaya – the secondary impact zone in Ethiopia.

Section 7.6 considers operational phase impacts in Sudan and Egypt – the principal secondary impact zone.

7.1 SITUATION AT BEGINNING OF OPERATION PHASE

Major impacts and mitigation measures for the 10-year construction period have been scoped in Chapter 6. This has included the time when turbines are tested and the power station is commissioned. At this time, Mandaya reservoir's storage contents are somewhere between MOL and FSL (but almost certainly not yet at FSL) and some power is being dispatched to consumers.

By this time, most of the construction workforce has long since disappeared from the camps, and (almost) all of the mitigation and enhancement works relating to contractors have been implemented and completed. Also, the resettled communities will have been living at their new village sites for some six or more years.

A small settlement will have become established at Mandaya, with former senior staff houses built for the construction period now being occupied by operational staff. Some shops, a restaurant or two, a police post, sports grounds, a school, clinic or small hospital, gardens and recreational facilities will exist, with treated reticulated water supplies and sanitation provisions. An airstrip for small aircraft, developed for the construction period, will continue to provide services, as may be needed. Modern communication facilities will exist, providing telephone, internet and TV services in this formerly remote area.

A visitors' centre will be available, displaying physical models of the project and providing video presentations of the project's history through its long planning and construction periods. In addition to the engineering (the biggest hydropower project in the Nile basin, among the largest in Africa), social and environmental aspects will be presented, including resettlement, flora and fauna of the area, and the progress of implementation of Abbay basin watershed management measures.

We may imagine that throughout each year, scores of coach loads of school children and numerous groups from all walks of life will visit the project in the operational period. According to schedules tailored for different categories of visitors, introductions to the project will be presented in the visitors' centre before visitors are taken to see and receive explanations of various components –

- the dam and gated spillway;
- the neck of the reservoir in the Mandaya Gorge;
- the intake, trash racks and boom;
- the mid-level and low-level outlets, reassuring downstream users of the built-in capacity to meet their needs if turbined flows are reduced for whatever reason;
- the powerhouse and switchyard, with explanation of the transmission system delivering electricity to Ethiopia, Sudan and Egypt and all the benefits for civil society and developments that flow from power trading and electricity supplies;
- the fish hatchery (for river and reservoir stocking) and aquaculture centre (with fish for sale in regional markets, and for cooking and serving to visitors);
- one or more resettlement villages where visitors may see host and re-established communities with their potable water supplies, good sanitation arrangements, a well-equipped school and health centre, fruit trees, shade trees, farmlands and livestock. The continuing support of the Mandaya project to resettlements, improving livelihoods and regional developments will be evident;
- the "table-top" view point (on the basalt capping, above either the left bank or right bank abutment) from which an exceptionally magnificent view of the project and surrounding country will be possible.

Importantly, a new bridge across Abbay will exist downstream of the dam, linking northern parts of Agelo Meti and southern parts of Sirba Abbay woredas, both on the left bank of Abbay, with Wonbera woreda on the right bank. Depending on project and regional government arrangements, it may be reasonably assumed that if a road link from Mandaya bridge to Wonbera (Debre Zeyit) has not already been established by project or other contractors (whether or not partly needed for the hydropower project construction), regional government will be pressing for this road to be constructed in order to take advantage of Mandaya bridge for joining the region together and promoting social services and economic development throughout the whole of Benishangul Gumuz region[1]. Thus, the Mandaya township will assume increasing importance as a route centre and may grow rapidly.

[1] The Abbay river divides Benishangul Gumuz region into two parts. There are no road bridges across the river within the region. Thus to travel from Asosa to Mankush in Guba woreda, a distance of only 160 km, requires driving more than five times this distance in a big loop upstream via Nekemte-Bure bridge and Chagni, a distance of 850 km. This lack of direct communication by road from the regional headquarters in Asosa to the northern woredas is a serious constraint for providing services and development in the region.

Because the Mandaya project is on an international waterway and requires close coordination, goodwill and agreements of three countries, it appears probable that a serviceable road will be required between Mandaya and Roseires in Sudan. This has not yet been incorporated in planning it is believed that this road link will be needed for the close collaboration required between the Mandaya project and Sudan's government departments and utilities for management of technical interactions. These concern flood forecasting and flood warning, regulation releases, opening and closing spillway gates, river gauging, water quality monitoring, fisheries development and the interconnecting transmission line to Sudan. Indeed, although telecommunications can and will provide routine links, it appears essential that managers, and technical and environmental staff of Mandaya and Roseires hydropower stations and reservoirs in particular can meet for survey and operational matters regularly without having to travel to Addis Ababa and Khartoum for this. When developed, this road route would open up possibilities of increasing trade between the two countries and even an "Abbay/Blue Nile tourist circuit" in future, with one or more hotels at Mandaya being central to this possibility.

In other words, transformation of this part of Benishangul Gumuz region may occur within a relatively short time. With these thoughts on how conditions at Mandaya township may be, we may consider the principal environmental and social issues relating to the Mandaya project in the operational phase.

By taking the time when Mandaya is commissioned as the cut-off point between construction and operation phases, and acknowledging that this is in practice a transitional phase extending over a few or many months, the majority of environmental and social impacts of the project have already been felt, as described in Chapter 6. Some of these impacts continue occurring in the operation phase and this has been already foreseen and introduced in the impacts and mitigations described for the construction phase. It is not the purpose to scope all these issues again here. This section therefore limits itself to mentioning important impacts in the operational phase, including some begun during construction, which will require continuing emphasis and follow up in EIA and RAP studies.

The major issues that will require overriding emphasis in the operational phase relate to the following: Environmental management and monitoring; Resettlement, development activities and monitoring; Dam Safety; Watershed management; Reservoir management; Environmental Offset(s) and Public Relations, Communications and Environmental Awareness. The need for these is apparent in this chapter.

7.2 HYDROLOGICAL IMPACTS

The primary operational impacts on environment of the Mandaya hydropower project are hydrological. Most other impacts are secondary or tertiary. Before considering operational impacts in this chapter, summary results of simulation of reservoir behaviour and downstream flows using the RAPSO model are described. These reservoir behaviour characteristics and regulated downstream flows are central to scoping many of the impacts associated with the project. The RAPSO model network is shown in Figure 7.1 and fully described in the Pre-feasibility engineering report.

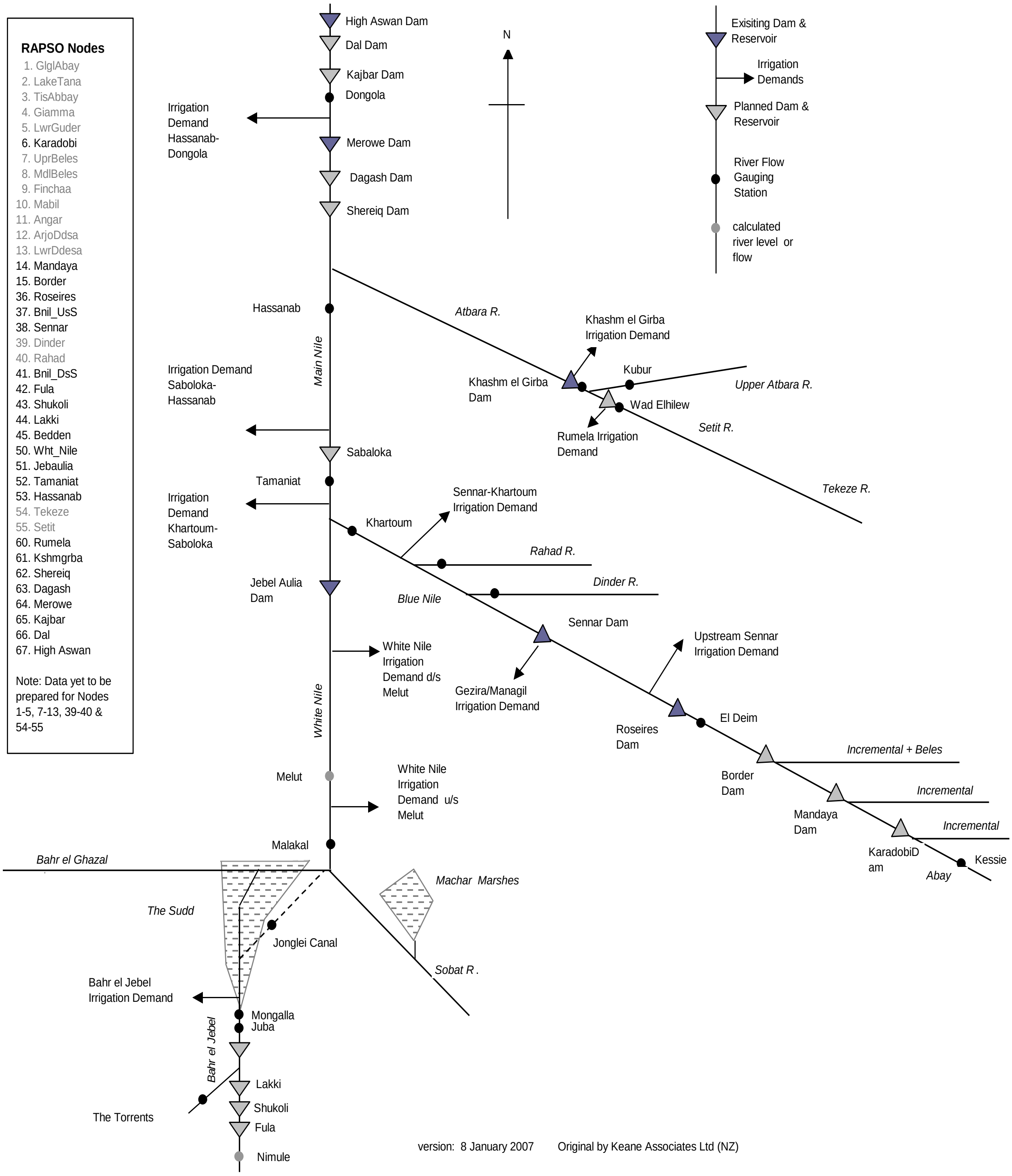


Figure 7.1 : Abbay and Nile system as modelled with program RAPSO

It is repeated here that dimensions of the Mandaya hydropower project (described in Chapter 3 and summarized in Table 7.1) are adopted for pre-feasibility study purposes. However, they are not optimized. The reservoir elevation/capacity/area relationship adopted in this study is considered reasonable but not as precise as would be required in a full feasibility study. Similarly, dam height, Full Supply Level, Minimum Operating Level, reservoir surface area, installed capacity, prescribed flows and regulation release patterns are not optimized and may change in any detailed feasibility studies that follow.

Table 7.1 : Mandaya Reservoir – Levels, Surface Area and Storage Volumes

Reservoir Level Characteristic	Level masl	Surface Area km^2	Volume $m^3 \times 10^9$
Full Supply Level (FSL)	800	736	49.2
Minimum Operating Level (MOL)	760	500	24.6
Difference between FSL and MOL	40	236	24.6

7.2.1 Summary of Simulations of Reservoir and Power Plant (2,000 MW) Operation

It may be seen that reservoir level vertical range is 40 metres. The reservoir surface area at FSL is 736 km^2. At MOL (the area permanently inundated) the surface area is 500 km^2. The operational surface area, which is variously inundated and exposed to air, is 236 km^2. Therefore, in Mandaya's case, the water surface area at FSL is slightly more than twice the area at MOL.

A 10-day inflow database was used for Mandaya reservoir simulations for the 50-year period January 1954 – December 2003. Components of the 50-year reservoir water balance generated by simulation of the project are presented in Table 7.2 where it is noted that 93% of flows are used in power generation and only 5% discharge through the spillway. A relatively small quantity of water (2%) is lost to evaporation.

Table 7.2 : Mandaya Reservoir 50 year Water Balance

Water balance component	Quantity m^3/s	Proportion of mean annual inflow %
Mean Annual Inflow	1,013	100
Turbined flow Spillway flow Total Downstream Flow	939 55 994	93 5 98
Evaporation losses	18.4	2
Mean of all outflows	1,013	100

Source: reservoir behaviour simulations, this study

7.2.2 Flood Flows

The annual frequencies with which Mandaya reservoir is at full capacity and downstream flood peaks are reduced are summarised in Table 7.3.

Table 7.3 : Summary of Maximum Reservoir Levels and Downstream Flood Peaks

Characteristic	Situation from interpretation of simulation results for 1,800 10-day periods in 50 years	Notes
Years when FSL is attained and spillway flows occur in at least one 10-day period per year	Spillway flows occur in 22 years out of 50. In some of the 22 years, spillways flows are very small indeed.	Spillway peak flows occur from 0 to 60 days later than natural flood peaks.
Years in which peak 10-day flood flows are reduced downstream	In 50 out of 50 years, peak flood flows are reduced by 1,100 m^3/s or more (range 1,121 to 4,832 m^3/s).	

In all years, downstream peak flood flows (10-day periods are considered here, not instantaneous floods) are reduced. Reductions are between 1,121 and 4,832 m^3/s.

In 21 years, there is no time lag between the peak of the natural flood and the peak of the regulated discharge. In 29 years, there is between a 10-day and 60-day lag time between the peak of the natural flood and the peak of the regulated discharge (Table 7.4).

Table 7.4 : Annual maximum 10-day flood peaks at Mandaya, natural and regulated (turbined plus spillway flows), lag times

Year	Month/ 10 day period (1,2 or 3)	Maximum Natural 10 day peak m^3/s	Month/ 10 day period (1,2 or 3)	Maximum Regulated 10 day peak m^3/s	Natural peak minus regulated m^3/s	Lag in 10 day peak days
1954	8/3	5526	9/3	3446	2080	30
1955	8/3	4766	9/3	3645	1121	30
1956	8/3	4602	10/2	2554	2048	50
1957	8/2	4910	8/3	1329	3581	10
1958	8/3	5594	9/3	2796	2798	30
1959	8/3	5529	9/3	3052	2477	30
1960	8/3	5232	9/3	2817	2415	30
1961	8/3	5196	9/2	3618	1578	20
1962	8/3	4531	10/1	2023	2508	40
1963	8/3	4848	9/3	2194	2654	30
1964	8/3	5646	9/2	3946	1700	20
1965	8/2	4144	8/2	1000	3144	0
1966	8/3	4084	8/3	1000	3084	0
1967	8/2	4488	10/2	2038	2450	60
1968	8/1	4202	8/2	1332	2870	10
1969	8/2	5913	9/2	3012	2901	30
1970	8/2	5546	10/1	1416	4130	50

Year	Month/ 10 day period (1,2 or 3)	Maximum Natural 10 day peak m^3/s	Month/ 10 day period (1,2 or 3)	Maximum Regulated 10 day peak m^3/s	Natural peak minus regulated m^3/s	Lag in 10 day peak days
1971	8/2	5165	8/2	1326	3839	10
1972	8/2	3330	8/2	1000	2330	0
1973	8/2	5832	8/2	1000	4832	0
1974	8/2	4994	8/2	1000	3994	0
1975	8/2	5362	9/3	3149	2213	40
1976	8/2	4487	8/3	1333	3154	10
1977	8/2	4991	8/3	1331	3660	10
1978	8/2	4027	10/2	1504	2523	60
1979	8/1	3855	8/1	1000	2855	0
1980	8/2	4343	8/2	1000	3343	0
1981	8/3	4158	8/3	1000	3158	0
1982	8/3	3937	8/3	1000	2937	0
1983	8/2	4755	8/2	1000	3755	0
1984	8/1	3349	8/1	1000	2349	0
1985	8/3	4687	8/3	1000	3687	0
1986	8/1	3753	9/1	1000	2753	0
1987	8/3	3579	8/3	1000	2579	0
1988	8/2	5827	10/2	2267	3560	60
1989	8/3	4536	8/3	1000	3536	0
1990	8/2	4128	8/2	1000	3128	0
1991	8/2	4587	8/2	1000	3587	0
1992	8/3	4363	8/3	1000	3363	0
1993	8/1	4522	8/1	1000	3522	0
1994	8/2	6163	9/1	4620	1543	20
1995	8/1	4044	8/1	1128	2916	0
1996	8/3	5686	9/1	3129	2557	10
1997	8/2	4083	8/3	1330	2753	10
1998	8/2	6937	9/1	4368	2569	20
1999	8/2	5510	9/1	3376	2134	20
2000	8/2	6167	9/3	2158	4009	40
2001	8/1	5983	9/1	4014	1969	30
2002	8/1	3939	8/1	1309	2630	0
2003	8/3	4480	10/1	1274	3206	40
Count		50		50	50	
Mean		4806		1917	2890	
Max		6937		4620	4832	
Min		3330		1000	1121	

Table 7.5 presents the same data as Table 7.4 but where the annual maximum 10-day flood natural peaks at Mandaya are not in historical sequence but ranked from largest to smallest, with corresponding regulated peaks shown alongside the ranked natural flood data. The differences between them are shown.

In the right hand column of Table 7.5, the differences between annual maximum 10-day flood natural peaks at Mandaya and corresponding regulated peaks (in column 4) are ranked from largest to smallest.

Table 7.5 : Ranked annual maximum 10-day flood peaks at Mandaya, corresponding regulated peaks, differences and ranked differences

Rank No.	Maximum Natural 10 day peak m^3/s	Maximum Regulated 10 day peak m^3/s	Natural peak minus regulated m^3/s	Rank No.	Natural peak minus regulated m^3/s
1	6937	4368	2569	1	4832
2	6167	2158	4009	2	4130
3	6163	4620	1543	3	4009
4	5983	4014	1969	4	3994
5	5913	3012	2901	5	3839
6	5832	1000	4832	6	3755
7	5827	2267	3560	7	3687
8	5686	3129	2557	8	3660
9	5646	3946	1700	9	3587
10	5594	2796	2798	10	3581
11	5546	1416	4130	11	3560
12	5529	3052	2477	12	3536
13	5526	3446	2080	13	3522
14	5510	3376	2134	14	3363
15	5362	3149	2213	15	3343
16	5232	2817	2415	16	3206
17	5196	3618	1578	17	3158
18	5165	1326	3839	18	3154
19	4994	1000	3994	19	3144
20	4991	1331	3660	20	3128
21	4910	1329	3581	21	3084
22	4848	2194	2654	22	2937
23	4766	3645	1121	23	2916
24	4755	1000	3755	24	2901
25	4687	1000	3687	25	2870
26	4602	2554	2048	26	2855
27	4587	1000	3587	27	2798
28	4536	1000	3536	28	2753
29	4531	2023	2508	29	2753
30	4522	1000	3522	30	2654
31	4488	2038	2450	31	2630
32	4487	1333	3154	32	2579
33	4480	1274	3206	33	2569
34	4363	1000	3363	34	2557
35	4343	1000	3343	35	2523
36	4202	1332	2870	36	2508
37	4158	1000	3158	37	2477
38	4144	1000	3144	38	2450
39	4128	1000	3128	39	2415
40	4084	1000	3084	40	2349
41	4083	1330	2753	41	2330
42	4044	1128	2916	42	2213
43	4027	1504	2523	43	2134
44	3939	1309	2630	44	2080
45	3937	1000	2937	45	2048
46	3855	1000	2855	46	1969
47	3753	1000	2753	47	1700
48	3579	1000	2579	48	1578
49	3349	1000	2349	49	1543
50	3330	1000	2330	50	1121

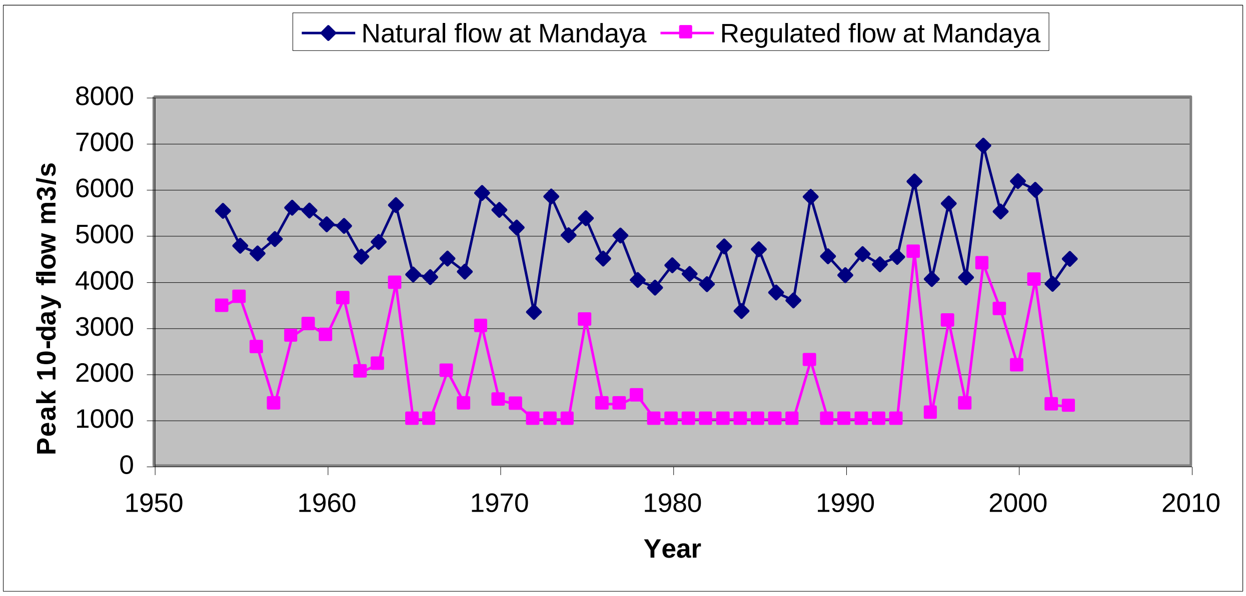
Rank No.	Maximum Natural 10 day peak m^3/s	Maximum Regulated 10 day peak m^3/s	Natural peak minus regulated m^3/s	Rank No.	Natural peak minus regulated m^3/s
Count	50	50	50		50
Mean	4806	1917	2890		2890
Max	6937	4620	4832		4832
Min	3330	1000	1121		1121

The 50-year historical sequence of annual maximum 10-day flood peaks at Mandaya, both natural and regulated (turbined plus spillway flows), is shown in Figure 7.2. As noted above, Mandaya spills in less than half of the years of operation. In these years when Mandaya does not spill, the regulated annual maximum 10-day discharge comprises turbined flows only. In order to meet seasonal downstream demands, a set of 12 prescribed monthly flows have been imposed on the RAPSO model. These apply to each of the three 10-day periods within the calendar month. The model is forced to make these releases. Thus, in tables above and in Figure 7.2, it is seen that the regulated annual maximum 10-day discharge is frequently 1,000 m^3/s, being the minimum discharge permitted in any of the three 10-day periods in the month of August.

The maximum power output (2,000 MW) occurs when Mandaya reservoir is full and providing a net head of 180 m. By contrast, the maximum power available in Augusts when the prescribed minimum flow is released is very variable, according to the head available for the reservoir contents at the time. Frequently, therefore, maximum power output does not occur in August because the reservoir is still recovering and filling, and not spilling. There are 78 10-day periods (of the 150 10-day periods) in Augusts when 1,000 m^3/s are released, occurring in 31 years out of 50.

This and other prescribed flows are presented in Table 7.6.

Returning to the annual maximum series in Tables 7.4 and 7.5 and Figure 7.2, it may be noted that all maximum flood flows are reduced, and that the mean annual natural flood (4,806 m^3/s) is reduced on average by 2,890 m^3/s to produce a mean annual flood under regulated conditions of 1,917 m^3/s. These reductions in flood flows, every year, will be felt down the Blue Nile and Main Nile.



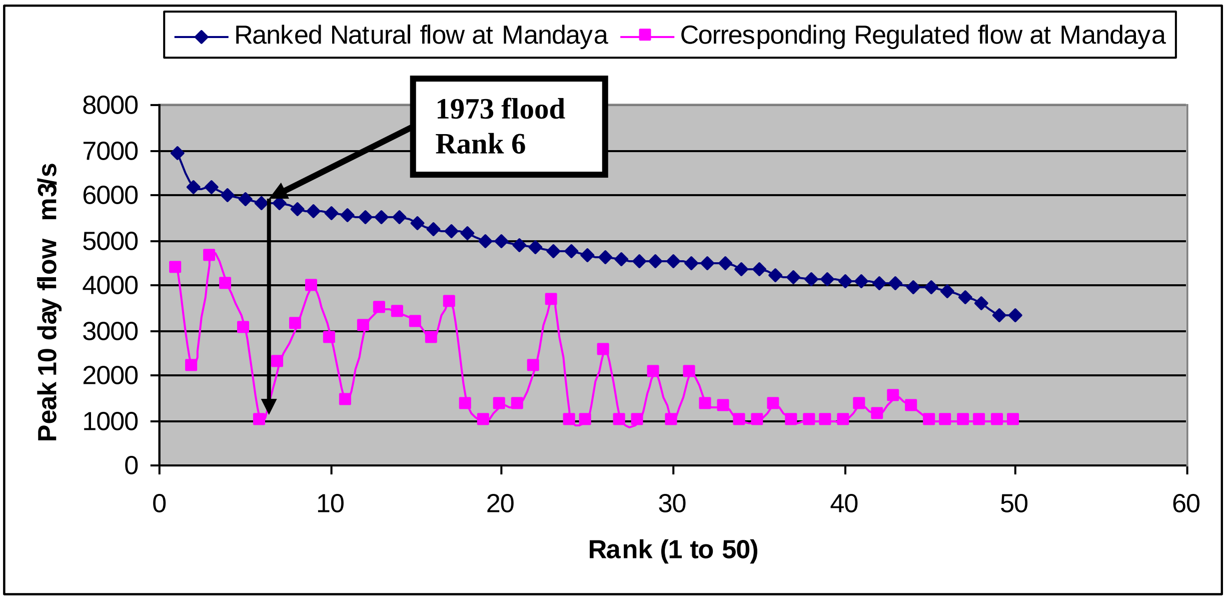
Source: RAPSO model output, this study

Figure 7.2: Annual Maximum 10-day flow series at Mandaya, 1954 – 2003

To the regulated releases at Mandaya will be added the natural flood flows of Dabus and Beles, Dinder and Rahad, restoring the Blue Nile's flood regime to some extent. However, because of the frequent "delays" in Mandaya's spillway discharges, in the years when they occur, Mandaya's contribution to peak flows and peak river levels downstream will occur later, frequently after the peaks of Dabus, Beles, Dinder and Rahad have passed. Thus on this account also, Mandaya will reduce flood flows and related flood levels in the Blue Nile and Main Nile.

The long run of years with a maximum discharge of 1,000 m^3/s between 1979 and 1993 when there is no spillway flow (excepting 1988) is remarkable.

Figure 7.3 shows the same data as in Figure 7.2 but where the natural annual peak flows are ranked from biggest to smallest. The corresponding maximum releases from Mandaya are shown. This shows that there is no predictable pattern to Mandaya's releases of high discharges. For example, the top ten natural floods (Ranks 1 to 10, and all above 5,500 m^3/s) are associated with a wide range of releases, from 4,620 to 1,000 m^3/s. The flood that occurred in 1973 is rank 6 in the 50-year record; it has the distinction of being reduced by the greatest amount – by some 4,800 m^3/s – because of Mandaya having low storage contents on its arrival and working hard to refill (see Table 7.4 and 7.5).

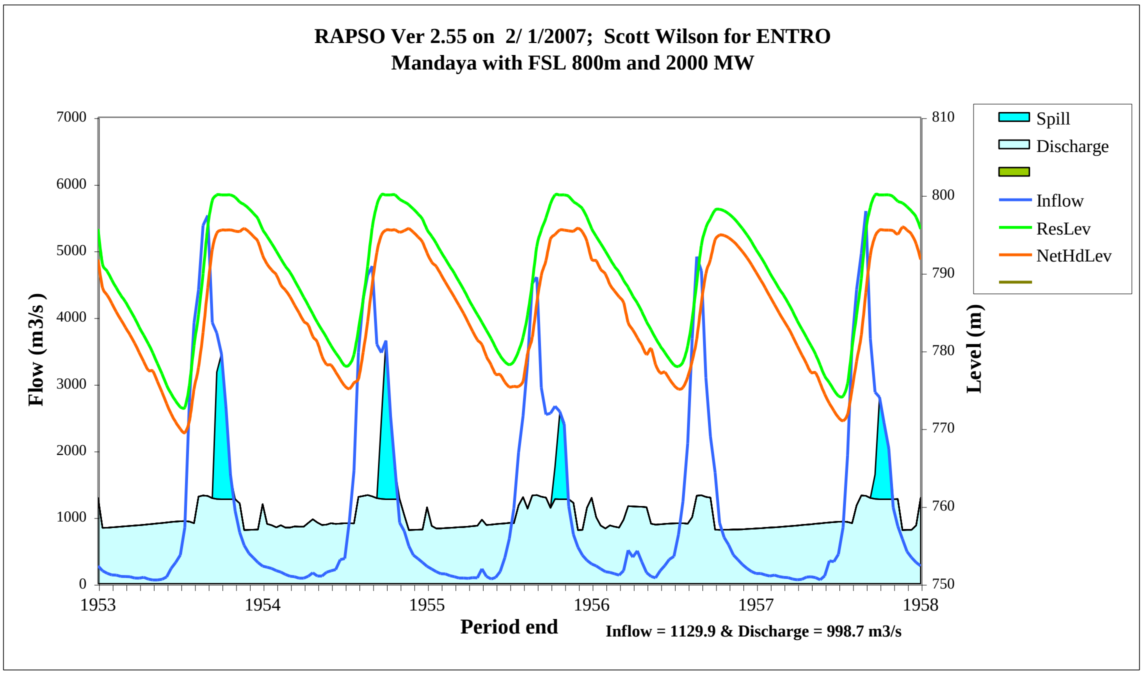


Source: RAPSO model output, this study

Figure 7.3: Ranked Annual Maximum 10-day flow series at Mandaya, 1954 – 2003

The several impacts of the reduction in flood flows are discussed later, and particularly in Section 7.6.6.

A typical 5-year period of operation of the Mandaya project as simulated by RAPSO is illustrated in Figure 7.4. The hydrograph is for 1954 to 1958 and shows four parameters of interest for environmental impact assessment: inflow, reservoir level, turbined discharge and spillway discharge. The turbined discharge sits at the base of the hydrograph. Spillway discharge sits on top of the turbined discharge, when it occurs, in or after the month of August.



Source: RAPSO model output, this study

Figure 7.4: Mandaya Hydropower Project Simulation, 1954 – 1958

In four of the five years illustrated, of the total regulated peak discharge (turbined flow plus spillway flow), the maximum turbined flow comprises about 1,270 m^3/s of the total peak flow. The remaining passes through the spillway.

In all years, Mandaya reservoir gains in level from the time when Abbay flood flows begin to arrive (usually in late May/June). As Abbay flood flows begin to arrive, power generation steps up quickly from its normal dry season generation of about 1,280 MW with six units operating Typically, the maximum turbined discharge is about 1,300 m^3/s for eight units giving 2,000 MW. This output typically occurs when reservoir level is within 7 m of FSL (and therefore some time before spilling occurs, or without any spilling).

The reservoir-refilling period occurs on the rising limb of the annual flood when sediment transport into the reservoir is at its greatest. This refilling period is shown as the uncoloured wedge under the inflow hydrograph.

The lag time between the natural inflow peak and the maximum regulated outflow is well illustrated in Figure 7.4. The record for 1957, without any spillway release, is a good example of a major reduction in flood flows downstream, and represents one of the 28 years in 50 years when no spillway discharge occurs.

7.2.3 Regulated Flows in Dry Season – Uplifts, Prescribed Flows and Reservoir Drawdown

Normally, as may be seen in Figure 7.4, turbined regulation releases far exceed natural inflows in the dry season. Average natural flows from January to May are in the range 110 to 170 m^3/s. With regulation, these averages are raised to over 700 m^3/s, an increment of well over 500 m^3/s (Table 7.6).

However, for the rare but important occasions when very severe drought occurs, downstream users require protection. For this reason, the RAPSO model was programmed to provide protection of downstream releases by prescribing protected or “hands off” flows for each month of the year – minimum flows that must be released. The adopted flows are shown in the first row of data in Table 7.6.

It may be noted that the prescribed flows for the five months January to May (all 100 m^3/s) are greater than historical minima, thus ensuring that under regulation conditions Blue Nile flows would not be lower than recorded historically – at least, not lower than in the 50-year record. The prescribed flow for August was set at 1,000 m^3/s (as discussed above). A “shoulder” of prescribed flows was placed in months around August of 200 and 300 m^3/s.

The frequencies with which these prescribed minimum releases were required during simulation are shown in the lower section of Table 7.6.

- In Augusts, as we have seen, they are called on many times.
- From September through to January, the prescribed flows are never called on; in these months, releases are greater than the prescribed flows in every year in 50 years;
- From February to July, the prescribed flows are called at least once and up to ten times, according to month. In total, the prescribed flows are released during 36 10-day periods in these months. All of these occur in the four years 1984, 1985, 1987 and 1988. These are the 36 occasions in the record (2% of 1,800 10-day periods) when energy shortfalls occur. Conversely, in 98% of time firm energy is reliable.

Table 7.6 : Prescribed Downstream Flows and Frequency of Occurrence

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum flow prescribed in model (m^3/s)	**100**	**100**	**100**	**100**	**100**	**100**	**200**	**1000**	**300**	**200**	**100**	**100**
Minimum natural inflow (m^3/s)	89	51	47	52	70	162	955	2774	1439	540	255	148
Mean natural inflow (m^3/s)	171	116	109	110	147	361	1916	4252	2753	1310	522	273
Mean regulated downstream flow - turbined flow plus spillway flow) (m^3/s)	872	835	852	880	861	901	1014	1184	1472	1258	878	907
Mean regulated downstream flow minus mean natural inflow (m^3/s)	701	719	743	770	714	540	-902	-3068	-1281	-52	356	634
(10-day Period) / month / year when prescribed minimum condition occurs in 50 year simulation	none	(1)/2/85 (2)/2/85 (3)/2/85 (2)/2/88 (3)/2/88	(1)/3/85 (2)/3/85 (3)/3/85 (1)/3/88 (2)/3/88 (3)/3/88	(1)/4/85 (2)/4/85 (3)/4/85 (1)/4/88 (2)/4/88 (3)/4/88	(3)/5/84 (1)/5/85 (2)/5/85 (3)/5/85 (1)/5/87 (2)/5/87 (3)/5/87 (1)/5/88 (2)/5/88 (3)/5/88	(1)/6/84 (2)/6/84 (1)/6/85 (2)/6/85 (3)/6/85 (2)/6/87 (1)/6/88 (2)/6/88	(1)/7/87	(1)/8/57 (1)/8/59 (1)/8/62 (2)/8/62 (3)/8/62 (1)/8/65 (2)/8/65 (3)/8/65 ***through to*** (1)/8/03 (2)/8/03 (3)/8/03	none	none	none	none
No.of 10-day periods when prescribed flow condition occurs	0	5	6	6	10	8	1	78	0	0	0	0
No.of years when prescribed flow condition occurs	0	2	2	2	4	4	1	31	0	0	0	0

The annual frequency with which Mandaya reservoir is fully drawndown is shown in Table 7.7.

Table 7.7: Summary of Reservoir Drawdown Frequency

Characteristic	Situation from interpretation of simulation results for 1,800 10-day periods in 50 years	Notes
Years when MOL is reached, or very nearly reached, in at least one 10-day period	MOL is reached, or very nearly reached, in five years out of 50 years: 1973, 1984, 1985, 1987 and 1988	Mandaya reservoirs draws down to,or almost down to MOL, exposing an area of reservoir floor/banks of 236 km^2

1973, 1984, 1985, 1987 and 1988 are the years with the lowest reservoir levels, reflecting poor rainfalls in preceding year(s).

The regular, year-by-year, uplift in low flows in the dry season (on average raised by over 500 m^3/s from January to May) will provide greater flows at Roseires, Sennar and Merowe power stations (and at any others constructed on cataracts of the Main Nile), permitting greater reliable energy generation from existing installed capacities, generally without additional works. This uplift in dry season flows also offers greater opportunities for increased abstractions for irrigation throughout the year in the Blue and Main Nile, as may be required. In areas where there are, or will be, river diversion structures for irrigation (e.g. as expected at Merowe), these abstractions will be made by gravity; in other areas without diversion structures, pumping will be required.

Because the prescribed low flow releases occur in a limited period of the year, and very rarely, irrigation planning schedules may be able to take these into account. For this, it should be possible to produce families of recession curves from the end of the wet season through to May and June the following year and from these forecast in November or December whether water shortages will occur in May and June, with reasonable accuracy. Such procedures are common on other projects. Adjustments to power generation releases and/or cropping patterns for the vulnerable period may then be made.

However, it is expected that Roseires and Sennar reservoirs would be operated conjunctively with Mandaya. These reservoirs are expected to operate at full supply level most of the time, giving maximum power output. On the few occasions when Mandaya would release prescribed low flows in the dry season, the storage in Roseires would then be used for power generation and supporting irrigation downstream. This should meet most, if not all, of the downstream irrigation demands when flows from Mandaya are restricted. In other words, with conjunctive use, Roseires should be able to ensure that downstream farmer’s irrigation demands are met. This requires more detailed study.

Alternatively, prescribed minimum flows may be raised (with some reduction in firm power generation and sales), or the 98% reliability of energy output could be revised and established at 100%. This would cause generation of a lower firm energy (and less energy sales) but would provide more protection for downstream users.

Furthermore, future planning could consider making provision for lowering the MOL in order to utilize stored water in what is currently the dead storage zone.

Thus, we draw attention to the Mandaya project improving downstream low flow conditions for most of record, and releases from Roseires' storage assisting irrigation supplies downstream when Mandaya releases are at a minimum.

7.3 PHYSICAL AND BIOLOGICAL IMPACTS – DIRECT IMPACT ZONE

The project's Environmental Monitoring Unit (and Resettlement Monitoring Unit) is expected to continue with its monitoring roles for many years, involving continuing close relationships with Mandaya project's management, woreda administrations and regional governments' headquarters.

Having developed experience of impact monitoring during the construction phase, the EMU will be well placed to develop a management and monitoring plan for its work for say, a five year program, and for individual years within that program. In collaboration with Mandaya's project management, the regional EPA and relevant government and research departments, and environmental agencies in Sudan, its important roles are likely to relate to the following aspects.

7.3.1 Water Levels, Flows and Sediment Concentrations

Mandaya's engineering managers will obtain reservoir water level and tailrace level records as a routine. A system is required to produce an ongoing water balance for the reservoir which will give outflows (turbined flows produced from megawatts generated, and spillway flows), net evaporation (losses from reservoir surface areas, rainfall and adjusted pan or Piche measurements) and changes in storage and derived inflows. Engineering hydrologists require this data. It is envisaged that the EMU will contribute to this, and ensure all necessary monitoring continues competently.

Not only are hydrological records required as good practice, they are needed with regard to compliance with conditions in any Concession Agreement (or other institutional/legal arrangement) which may apply to the Mandaya project. Thus records of downstream discharges will be required as evidence of Concession Agreement conditions being met, including prescribed minimum flows to maintain acceptable conditions in the event of scheduled or unscheduled maintenance and plant shutdown. These conditions may change as years pass and experience is gained. The earlier records will be essential for reviewing releases and considering or proposing new ones.

It is expected that a river gauging station will be installed downstream of Mandaya dam site during feasibility studies, and calibrated. The flow and suspended sediment transport records of this station will need to continue in the operational phase. It will require maintenance and re-calibration. This work will inevitably be facilitated by good accommodation for Ministry hydrologists being available at Mandaya.

There is also need for the existing river gauging station further downstream at Border to be refurbished. First class records of levels, flows and sediment transport are required for this station, indefinitely. This is even more important in view of the important El Deim station across the border in Sudan being expected to cease operations in the near future owing to the imminent raising of Roseires dam.

At intervals of say five years, reservoir sedimentation surveys will be required for operational purposes, in particular to revise the elevation/storage curve and revise assessment of reservoir yield. A boat with specialised equipment will be required for this. Arrangements for these surveys will be made by the project Owner.

The results of these surveys, and the monitoring results of sediment transport downstream of Mandaya dam (and at the resuscitated gauging station at Border) will also be required by agencies implementing the Abbay watershed management program.

The need for laboratory facilities at Mandaya in the operation phase should be considered before construction commences. The contractor will establish a materials testing laboratory for the construction phase and the Owner, EMU and others may require this facility in the operations phase (for analysis of suspended sediment samples, river and reservoir water quality samples, well and borehole water samples, etc).

7.3.2 Reservoir Yield -Sedimentation

Mandaya's gross storage volume (49.2 billion m^3) is subject to siltation. The rate of this is unknown, sediment sampling at Kessie, and at Border and El Deim gauging stations downstream of Mandaya, being inadequate to provide an up-to-date assessment. The current estimate of 285 Mt/year is based on a very small sample of sediment sampling at Kessie in 2004 and the assumption that the yield of the catchment area between Kessie and Mandaya is now as the Kessie catchment was in 1960-61. This estimate and the sediment sampling situation are not satisfactory. The estimate of 140 Mt/year based on El Deim is also unsatisfactory, being based on samples taken at the river bank and a long time ago. There is therefore urgent need to establish a gauging station at Mandaya and to rehabilitate the Border gauging station downstream, intensify sediment sampling and to produce up-to-date assessments of sediment transport at this key location.

The useful life of Mandaya reservoir is unknown and unknowable in these circumstances but if for comparative purposes the assumption is made – a simplistic assumption – that the reservoir operates as a 100% efficient sediment trap, some 240 years is indicated, adopting a settled density of 1.4 tons per m^3.

The impact of reservoir sedimentation on Mandaya's yield for power generation and for downstream regulation has not been studied but it is clear that both will deteriorate as soon as sedimentation begins to take place in the live storage zone.

Mitigation measures have been discussed in Chapter 6.

7.3.3 Reservoir Yield – Climate Change

Mandaya's future inflows have been assumed to be similar to past records. No adjustment for climate change is currently justified because there is no agreement among scientists on the impact of global warming on annual rainfalls.

7.3.4 Reservoir Yield – Water Supplies, Irrigation and Water Transfers

The impact of upstream consumptive use abstractions on Mandaya's yield for power generation and for downstream regulation has not been studied. Reservoir yield will reduce as these increase in future. The reduction in reliable yield is likely to be very small compared to reduction in yield associated with loss of live storage capacity because of sedimentation.

Consumptive use abstractions in the Abbay basin have not been deducted from Mandaya's reservoir inflows in pre-feasibility RAPSO model simulations. They are believed to be small and within the error margins of the flow record. In future studies, the flow record will need to be worked up and documented thoroughly, and naturalised for historical consumptive use abstractions. It is then that future projections of consumptive use abstractions will be required, and deducted from the inflow record. Apart from allowing for growth in existing consumptive use, account can then be taken of proposals for new irrigation schemes and any water transfers out of the Abbay catchment area, e,g. for Addis Ababa.

7.3.5 Reservoir and Downstream River Water Quality

Impacts on water quality in the operational period are unknown. They may be estimated, as stated earlier, by use of a water quality model during feasibility studies.

The EMU with the project Owner will need to prepare and implement a water quality monitoring program for Mandaya reservoir and releases downstream (both turbined discharges and spillway discharges). A boat will be required for reservoir surveys. Samples should be taken from a network of locations at different depths and the results archived and plotted. As the record continues, it will assist understanding of algae blooms, weed growth, primary productivity, any sulphur dioxide gas releases at the tailrace, etc. Apart from usual physical and chemical parameters, consideration should be given to monitoring suspended sediment in turbined and spillway discharges – monitoring which is often overlooked. Concentrations will change according to seasons, and according to the changing trap efficiency of the reservoir.

7.3.6 Climate

The EMU should continue climatological records begun at Mandaya during the construction phase. Micro-climate impacts of the reservoir are not expected to be significant but records should be collected for general purposes. The rain gauge network may be extended according to the accessibility of sites created by new roads and tracks, and the availability of reliable observers. However, the usual choice of installing rain gauges at schools should be given very careful consideration; records from schools in rural areas are notoriously disappointing, both in quality and continuity, owing to frequent changes in staff. The project climate station and any additional rain gauges will be satisfactorily sited and these stations should therefore meet requirements of the federal meteorological agency and be formally registered.

7.3.7 Project roads and Reservoir Banks Slope Failures

Some slope failures may be expected in the project area. Some susceptible areas will have been noted and treated during construction activities. Engineering works for treating slope failures and reducing erosion will be carried out by the responsible agency, normally the project owner or roads authority for non-project roads.

7.3.8 Groundwater and Springs

As noted earlier, groundwater levels will rise significantly around the reservoir in areas where rock types are not impermeable and geological structures are favourable. Such areas are not thought to be extensive but there are likely to be some. Once groundwater levels are established after first filling, they will fluctuate according to rainfall received and in part according to the 40 m range in Mandaya reservoir levels. Whilst seepage losses from the reservoir are not expected to be significant from a project point of view, the availability of groundwater nearer to the land surface, and any new springs, may be valuable new resources for water supply for existing and resettlement communities.

Monitoring of any observation boreholes established in the construction period should continue in the operational period. Favorable areas should be considered for development of water supplies for local communities.

7.3.9 Terrestrial Ecology

In the operational period, it is anticipated that environmental management will require wildlife habitat and wildlife surveys to be conducted around the reservoir margins and buffer zones and in environmental offset areas (e.g. Dabus valley) promoted by the project in partnership with federal and regional wildlife authorities (e.g. Ethiopian Wildlife and Natural History Society).

Also, it is anticipated that waterfowl surveys for Mandaya reservoir will be conducted and results submitted to Ethiopian and international agencies that coordinate waterfowl monitoring and reporting in Africa (African Waterbird Census, International Waterbird Census, BirdLife International, Wetlands International).

7.3.10 Aquatic Life and Fisheries Development

In the operational period, it is anticipated that reservoir management will require aquatic surveys to be conducted in Mandaya reservoir and its tributaries, and that these will be coordinated with aquatic surveys in the lower reaches of Abbay and at Roseires reservoir. Surveys will include phyto-plankton, zoo-plankton, benthic fauna and fish. Such surveys should also be coordinated with water quality surveys if possible, or at least utilise the results of water quality monitoring.

Fish surveys should include information on fisheries development and management at both Mandaya and Roseires reservoirs and the results used to inform and improve fisheries management of the reservoirs in the light of the annual reservoir level regime at Mandaya and the new conditions at Roseires (less sediment, greater light penetration, etc). Sennar reservoir may also be included.

The water quality, hydrological and aquatic surveys should contribute to a post-construction impact assessment of Mandaya reservoir and the Blue Nile downstream, similar to the work of the Hydro-biological Research Unit for Roseires in the 1960s and subsequently.

An opportunity to sample fish for research purposes may become available below Mandaya's spillway after spilling, and rarely at the Mandaya tailrace. Typically, numerous fish may be netted when spillway gates close and fish become stranded. To arrange for fish biologists to obtain these samples (for species identification, length, weight, sex, development of gonads, etc), good awareness and coordination is required between the project owner (who anticipates the closing of one or more gates), EMU and research agencies. These opportunities are frequently unrecognised and not used. Fish in this sampling, as has been done occasionally below Roseires reservoir, may or may not be distinct from fish in reservoirs and much additional information may be learned about the Abbay/Blue Nile's fish population and migratory habits from this. This may contribute to exploitation and conservation practices, and assist planning of other water resources developments in future.

In keeping with the multinational aspects of Mandaya's development, continuing close liaison is expected to continue in the operational phase, including jointly conducted surveys and exchange of data between Mandaya and Roseires reservoir managers.

7.4 SOCIO-ECONOMIC IMPACTS IN OPERATION PHASE

As stated earlier, by taking the time when Mandaya reservoir first fills as the cut-off point between construction and operation phases, the majority of environmental and social impacts of the project, described in Chapter 6, have occurred by the beginning of the project operation phase. Some of the major initial social impacts are over, such as the arrival and presence of a large construction workforce (now gone) and house and property moving of the resettled communities (now living at their new village sites for some six years). A small town will have become established at Mandaya and, as anticipated earlier, the new bridge across Abbay may be connected to Wonbera (Debre Zeyit) linking Asosa, Sirba Abbay and Agelo Meti to woredas on the east bank of Abbay and providing the possibility of promoting social services and economic development throughout the whole of Benishangul Gumuz region.

These new developments and improved regional communications should facilitate services required for the on-going care and development of the project's host and resettlement communities. It may be anticipated that the RAP and development plan will now have been updated by the RMU and local administration and provide for detailed monitoring of the mitigation measures implemented during the construction phase. Project funds, from Mandaya's income stream from energy sales, should be available for addressing residual liabilities of the project, in line with recommendations of the World Commission on Dams report in year 2000.

7.4.1 Electricity Supplies

The primary purpose of the Mandaya hydropower project is to increase power generation and trade within the Eastern Nile region, namely Ethiopia, Sudan and Egypt.

Power generation from the project has been estimated by simulation of Mandaya reservoir behaviour and the 2,000 MW installed capacity of the power plant over a 50-year period, giving a reliable firm annual energy generation of 11,194 GWh/year, and average annual energy (reliable firm energy plus discretionary or dump energy) of 12,119 GWh/year. Summary simulation results are presented in Table 7.8 for the Mandaya base case (as a stand-alone project), and for other cases as stated. Some 10% or more of generated energy may be expected to not reach consumers owing to unavoidable transmission losses. The benefits of these additional supplies are legion, stimulating industrial developments and employment and improving civic and domestic living conditions in areas supplied.

Table 7.8 : Summary Energy Simulation Results

Option	Installed Capacity (MW)	Energy Output (GWh/year)			
		Base		With Mandaya	
		Firm	Average	Firm	Average
Karadobi	1,600	8,276	8,802		
Mandaya FSL 800	2,000	11,194	12,119		
Border	1,200	3,966	6,011	7,429	8,114
Low Dal	340		1,944		2,187
Uplift at Existing Power Stations	0				2,211
Uplift at Existing Power Stations	135*				2,657

* Additional plant at Roseires

The cooperative international institutional arrangements to facilitate this major development (owners, lenders, tariff agreement) and power trading are not yet determined but some idea of the potential sale value of the electricity generated at Mandaya may be gained by considering that the annual sale of firm energy alone at US cents 4 per KWh implies sales worth some USD 448 million/year.

The generated energy will be transmitted to the Ethiopian grid at Sululta or Debre Markos and to the Sudan grid, outside of the direct impact zone. A local low voltage supply will be provided to the project and project facilities (with diesel generator backup facilities). Extensions of this local distribution are not planned at pre-feasibility stages of planning but cases for negotiating greater rural electrification provisions in the future planning process have been made in Chapter 6, Sections 6.5 and 6.6.

7.4.2 Resettlement, Development and Monitoring

At Mandaya, the estimated numbers of households to be resettled are relatively low, and very low for a project of Mandaya's size:

- In the Mandaya reservoir basin, communities with an estimated 600 inhabitants comprising 120 households. The affected woredas are Yaso in Benishangul Gumuz and Wonberma in Amhara region.

- In the villages affected by the dam construction activities, about 1,020 people comprising 204 households. The villages are downstream of the dam site in Sirba Abbay woreda.

For these resettlers, for whom most now exist with an income of less than USD 1.0/day, there will be pressing need to ensure that livelihoods are improved, not just maintained, and certainly not made worse. The project owners and financiers will wish to see and know that improvements have been achieved in living conditions, and are continuing to improve in the project operation phase. This is the spirit required and which needs to be converted into reality. The presence of a new major project and new town (Mandaya) in the vicinity will be a constant reminder of the cause of resettlement and, by comparison, a never ending source of grievances if the project fails to deliver satisfactory services.

With these and other points in mind, the RMU will have already sought to ensure, and will continue to monitor, that the following are satisfactory, or developing inexorably to a foreseeable satisfactory condition, for all people without exception:

- New houses
- New housing suitable for all kinds of livestock
- Mosquito nets
- Water supplies
- Sanitation provisions
- Drainage arrangements
- Roads and footpath networks
- Clinics, and qualified health care staff numbers
- Schools, and qualified teaching staff
- Community buildings and facilities, including market places
- Energy sources
- Shade trees

The RMU will also have already sought to ensure that livelihoods have been re-established and improved, including carrying out monitoring of the following:

- family incomes
- agricultural production
- tree production
- livestock production (chickens, goats, sheep, cattle, donkeys) and grazing resources
- fish, honey bee, and non-timber forest products and related activities.

The RMU will also be responsible for ensuring on-going provision of satisfactory veterinary, agricultural, horticultural and other specialist advisory and treatment services.

The resettlement locations are undetermined but are likely to involve all three woredas (Yaso and Sirba Abbay in Benishangul Gumuz, and Wonberma in Amhara) and therefore three woreda administrations in two regions. Though not a large number, this presents a potential difficulty for the project and RMU compared to having one woreda. Standards of resettlement and service provision to resettlements require being very high. A list of some potential resettlement sites, identified by Benishangul Gumuz government, is given in Chapter 9.

In addition, RMU monitoring should cover the estimated 275 households who live outside of the project area but who will have been compensated for loss of their cultivated areas in the reservoir basin following first filling. Alternative sources of income generation are required to replace this loss (separately from the compensation). The RAP plan, outlined in Chapter 9, and its updates will cover these also, although resettlement itself is thought not to be required.

7.4.3 Independent Auditing

At intervals, independent auditing and monitoring will be required for all host and resettled communities. Any targets set in the RAP and development plan, and in later editions (original targets, or otherwise subsequently revised) must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to local communities and woreda administrations, regional governments, NGOs and project financiers.

Failures to achieve targets should result in immediate measures to improve conditions. Financial provision for such contingencies to mitigate and improve conditions should be made available from Mandaya project's income stream, over and above annual allocations of funds. The mechanism for this needs to be established early in the project, and contractually agreed. The proposed independent Panel of Experts for the Environment and Community Protection during the construction phase should advise on this. It will not be acceptable to pass requests for finance for continuing support of the resettlement communities to a series of committees in Addis Ababa. The annual allocation of funds, and provision for contingencies, needs to be available through project management at Mandaya, with well-devised procedures involving stakeholders (possibly through a Trust Fund, with banking facilities at Asosa or Mandaya New Town) to support a range of maintenance and development measures.

All of this needs to be on the agenda early in project preparation, and clarity sought about the roles of the regional governments and woredas and the project. All provisions should be tabled and clarity sought on such things as who will pay for salaries of teachers, nurses, technicians and others in resettlement areas, maintenance of infrastructure, supply of drugs at clinics, replacement of mosquito nets, etc, and for how many years before any changeover. All of these things require to be worked out, declared and known by all.

7.4.4 Miscellaneous Important Matters

Scoping of principal social issues relating to the operational period have been outlined above. These need to be taken up in future RAP and development studies.

There remain some related important issues about which brief comments are made in subsequent sub-sections.

7.4.5 Irrigation

Our scoping of issues about resettlement and irrigation raises a number of questions. These cannot be answered without conducting full rural sociological and land resources surveys, but the following points are considered relevant.

There is no known irrigation around the potential reservoir area or in other adjacent areas where resettlement may take place. For these communities, it is considered that a change from subsistence farming, often with a strong element of shifting agriculture to sedentary farming, will be difficult for many in the early years of resettlement. A change directly to small-scale irrigated farming will be even more difficult (though for some, irrigation may be successful). As the years pass, aptitudes for irrigation farming may change and the presence of Mandaya reservoir in the neighbourhood will inevitably raise questions about utilizing water from it for irrigation – not so much around the reservoir's margins because they are steep and the operating range is 40 m, but in a downstream direction where slopes are more favourable and Abbay's regulated flows will be available. Indeed, some may request provision be made for gravity fed or pumped irrigation downstream of Mandaya dam.

Without the benefit of the surveys mentioned, our current thinking is that irrigation development is one to be considered but that it may not be appropriate and successful for some years to come.

7.4.6 Access across Mandaya Reservoir

Current information suggests that there are no, or very few, crossing places of the Abbay and Didessa rivers in the potential impoundment area. Small ferry boats (feluco) and footbridges across the narrowest sections of the reservoir are expected to be required in future. Ferries will have to operate over an annual range of levels of 40 metres, making safe access across muddy and slippery banks potentially difficult for people and livestock. The same applies to fishing boats for which ramps may be required. As experience is gained, communities (supported by the RMU) may require improvements and more of these facilities. Budgets will need to accommodate provision for these.

7.4.7 Fisheries

After an expected flush of nutrients released from rotting vegetation and associated high productivity in the aquatic food chain, particularly in the first five years, Mandaya reservoir may offer sustainable employment and fish-related commercial opportunities. It is expected that fishing will be modernized and systematically developed for markets in the project and surrounding areas. Local capacities should be developed through training and adoption of appropriate technologies. Budgets will need to accommodate provision for these.

7.4.8 Pollution

Although local pollution sources for Mandaya reservoir are not expected to be large, it is conceivable that portions of the reservoir may require special measures to prevent transmission of water-related diseases, local reservoir sedimentation and pollution by livestock and human populations. Any necessary restrictions will need to be explained to local communities and their support sought for them.

7.4.9 Archaeological and Historical Sites

No known archaeological or historical sites have been identified but this does not mean that there are none. If made known or discovered in future, these may be candidates for project support.

7.4.10 Employment

Relatively few employment opportunities will be created by the project itself in the operation phase. Most jobs available relate to very skilled, skilled and semi-skilled work. It may be hoped that some of these may go to local persons trained and apprenticed during the construction period. (The need for this training in the pre-construction and construction period was mentioned earlier in Chapter 6 and in Appendix 4.11 – A nurse's view).

7.4.11 Commercial and Trade Opportunities

Commercial and trade activities may be expected to develop substantially in and around the project area because of new demands for goods and services at Mandaya New Town, resettlement areas and improved communications. However, these may grow further or stagnate according to the policy adopted on provision of rural electricity supplies.

7.4.12 Rural Electricity Supplies

It is often thought that new hydropower projects will provide electricity to surrounding areas, and at a "reasonable" tariff. Furthermore, it is argued that this provision will reduce dependence on traditional energy sources, and that this will contribute favourably to reducing erosion and maintaining wildlife habitat.

Unfortunately, this has rarely been the case in the past. High voltage transmission lines passing overhead (to Sudan and to Sululta or Debre Markos) are definitely not suited to local distribution where low voltage lines are needed. These low voltage lines can be provided to the area from the project's switchyard, and/or by extensions from the nearest areas currently supplied.

In the case of Mandaya, where a lot of land will be sacrificed for developments in faraway places, it may be very reasonably argued that the project should look after and pro-actively promote development of surrounding areas, and Benishangul Gumuz and Amhara regions in general. This is scoped here as a major issue for the project promoters and Benishangul Gumuz and Amhara governments.

It is one that may be resolved by giving close attention to potential energy needs of existing and potential industries and communities in the region. Domestic electric lighting is associated with very low demands, particularly if settlements are sparsely distributed. But if extraction industries (e.g. marble, limestone for cement), materials processing and substantial water pumping (e.g. for process industries, irrigation) are involved, particularly if located in close proximity, their energy demands are more likely to justify new supplies; otherwise, diesel generators are normally appropriate.

Another major factor in this equation is the ubiquitous poverty in the project woredas. There is an opportunity for the project, and for financiers, many of whom support the slogan to "make poverty history", to do their best to kick start rural development in an area adjacent to a new 2,000 MW power station. As stated earlier, surveys are required to demonstrate what electricity demands may be in the area in order to determine which sources of energy are best suited to meeting these.

7.4.13 Public Relations, Communications and Grievances

As foreshadowed in the construction phase, opportunities for misinformation and misunderstanding are many and every effort has to be made to avoid these. In the operations phase of the project, the public relations and communications system will need to continue. The principal operational impacts are mentioned in this section but the public in downstream woredas, and in Sudan making use of the Blue Nile and Main Nile, and the public in Egypt benefiting from High Aswan Dam will be keenly interested in how operational impacts will affect them.

The project will need to continue with a first class public relations and communications system for all aspects of the project. Information needs to be communicated in Ethiopia, Sudan and Egypt and care taken that it reaches all relevant stakeholders effectively.

7.4.14 Dam and Public Safety

Reports of the Panel of Experts on dam safety will have been made available to the public during the construction phase. In the operation phase, there will be keen public interest in dam safety and engineering operations, including releases of water according to the agreed program and maintenance of failsafe systems for flood forecasting and warning, the operation of spillway gates at Mandaya and inevitably for the operation of releases and spillway gates at Roseires.

7.4.15 Project Induced Developments

Project induced developments are commonly overlooked in project design and implementation. They are related to secondary growth that could arrive or pre requisite the project implementation. These induced impacts cannot be predicted on a reliable basis, rather suggested based on experience of implementation of similar projects in the region and elsewhere.

As discussed in the socio-economic section, the project area and the Benishangul Gumuz region as a whole is deprived of major infrastructure facilities such as roads, electrical energy supplies, communications, etc. and settlements are very dispersed. The scale of the proposed project development requires a large skilled and unskilled labour force brought mainly for the 10-year project construction period. This is a long period during which there will be impacts on traditional communities. The present poor infrastructure, economic opportunities and other services will be improved spontaneously due to the project implementation; this may later attract people from the surrounding areas and from further a field. In-migration could be temporary or permanent. The experience of hydropower development construction sites in Ethiopia shows that small construction sites can be transformed into large towns and commercial centres. The major impacts associated with project induced developments include: -

- Pressure on existing public services and institutions including water supply, health and education
- Increased pressure on health and sanitary facilities
- Breakdown of traditional methods of social control

Mitigation measures for these can include:

- Training local people beforehand, especially for the less skilled jobs, making special efforts to provide training for local minority peoples; improving transport facilities to and from the site to enable local people to work at the sites.
- Planning new infrastructure and services adequately for the voluntary immigrants as well as the unknown numbers of construction workers coming to the project area.
- Promoting investment in local resources such as fisheries, poultry and others to improve the local resource base and capacity to produce food or services for sale to the migrants.
- Locally, strengthening existing institutions or developing new ones to undertake long-term development and regional planning that addresses changes, to handle an increased number of disputes and social problems, and to accommodate a much more diversified population.
- Planning adequate health, drinking water and sanitary facilities to deal with the unexpected rise in the incidence of disease and pest problems.

With these points in mind, attention has been drawn earlier in this report to implementing health education/awareness and improving health services to vulnerable communities (for those not specifically included in RAP and associated development plan); implementing plans for preferential employment of local people, with training; making salvaged timber from construction sites, including reservoir basin clearance, available to local communities; and accelerating plans for rural electrification in the region. These are specifically mentioned in the draft EMP in Chapter 9 where the plan also includes a requirement to anticipate, plan for and implement measures for non-specified project induced developments.

7.5 OPERATIONAL PHASE IMPACTS DOWNSTREAM OF MANDAYA IN ETHIOPIA

Some of the impacts on the lower reaches of Abbay experienced in the construction phase will continue in the operational phase. Mitigation measures carried out earlier will apply.

7.5.1 River Crossings and Safety Issues

In the operational phase, changes in seasonal release patterns will occur as prescribed in the Owner's requirements. The agreed release rates incorporated in the Owner's requirements will require increasing and decreasing downstream flow rates at certain times of the year for energy generation purposes, releasing spillway flows and also to safeguard riparian interests downstream in times of drought when Mandaya's storage contents are extremely low.

It is expected that river crossings of Abbay by small boats (felucos) – effectively "ferry" services for people in Sirba Abbay, Guba and Wonbera wordedas and from further afield – will be generally undisturbed by Mandaya's operations. However, the potential will exist for rapid changes in water levels, particularly when the spillway gates are opened and closed.

Downstream warning measures will be required in advance of changes in release rates. These measures should be included in the Owner's requirements and in the flood forecasting and warning scheme operated by the Owner.

7.5.2 Recession Agriculture

The loss of flood recession agricultural areas, estimated at 2,400 ha, will have been mitigated in the construction phase, either by monetary compensation or by provision of small-scale irrigation facilities. As described earlier, and again later in Section 7.6.6, Abbay flood flows in the operational phase will be greatly reduced.

If the earlier mitigation has been to provide small-scale irrigation facilities, these should continue and, if successful, may expand. There will be potential for two crops each year instead of one. The RMU will be required to monitor these conditions and ensure that livelihoods of affected households are satisfactory and improving.

7.5.3 Gold Panning

In the operational phase, when dry season flows are significantly raised, opportunities for gold panning in the lower Abbay river channel will probably effectively cease. Compensation will have been provided during the construction phase. Gold panning will be able to continue in Abbay tributaries as before.

7.6 OPERATIONAL PHASE IMPACTS IN SUDAN AND EGYPT

7.6.1 Electricity Supplies from Mandaya project

The primary purpose of the Mandaya hydropower project is to increase power generation and trade within the Eastern Nile region, namely Ethiopia, Sudan and Egypt.

Summary simulation results of firm and average energy generation have been presented in Table 7.8. The potential sale value of the electricity generated may be gained by considering that the annual sale of firm energy at US cents 4 per KWh implies sales worth some USD 448 million/year. It is planned for Mandaya power to be transmitted to Ethiopia and to the Sudan grid at Hasaheisa/Rabak for onward transmission in Sudan and to Egypt (subject to further planning).

Cases for negotiating greater rural electrification provision in the Blue Nile valley have been made in Chapter 6, Section 6.6, with regard to future planning. The Mandaya high voltage supply to Sudan is not suitable for this.

7.6.2 Electricity Supply Uplifts in Sudan

River regulation by Mandaya reservoir operations will increase dry season flows from Mandaya tailrace to High Aswan Dam. The regular, year-by-year, uplift in low flows in the dry season (on average raised by more than 500 m^3/s from January to May, Table 7.6) will provide greater flows at Roseires, Sennar and Merowe power stations (and at any others constructed at cataracts on the Main Nile), permitting greater reliable energy generation from existing installed capacities in the Sudan cascade, generally without additional works.

The effects of the Mandaya project on generation at existing hydropower projects in Sudan have been estimated by simulation (Table 7.9).

Table 7.9 : Uplift in Generation at Sudan Hydropower Projects due to Mandaya

Option	Average Energy Output GWh/year				
	Roseires	Sennar + Ext.	Merowe	Total	Uplift
Base Case, Existing with Roseires flushing operation	1436	302	5903	7640	0
With Mandaya, with Roseires flushing operation	2142	490	6263	8895	1255
With Mandaya, without Roseires flushing operation	2304	521	7026	9851	2211
Roseires MOL raised to El. 471 and 3 x 45 MW extension	2750	521	7026	10297	2657

It is a remarkable feature that the expected uplift in energy generation at Roseires, Sennar and Merowe (1,255 or 2,211 GWh/year), resulting directly from Mandaya holding back much of the silt (though Dabus and Beles continue to deliver sediment) and regulating flows, can be achieved without explicit or substantial capital expenditure in order to reap the rewards of river regulation.

The uplift of 2,211 GWh/year in Sudan, for the case without flushing at Roseires, is greater than the preliminarily estimated energy generation at Low Dal which would involve a substantial capital outlay (project engineering cost USD 1,130.9 million), loss of productive land, a major resettlement program, a major archaeological survey and salvage program and a large loss of water by evaporation. Dal's annual evaporation losses, expressed as cubic metres of evaporation per GWh/year, are nine times greater than for Mandaya. Thus, the uplift of energy generation in the existing power cascade in Sudan is not only to be valued in energy terms but may be valued in wider environmental, social and cultural terms also.

The potential sale value of the electricity generated may be gained by considering the case without Roseires flushing operations following construction of Mandaya. The annual sale of the uplift of energy at US cents 4 per KWh implies sales worth some USD 88 million/year.

7.6.3 River Hydraulics

Substantial changes to river morphology may be expected in Sudan in Mandaya's operational phase. This is demonstrated by the change in flow regime (Tables 7.4, 7.5 and 7.6).

The normally expected rise in water levels will be reduced when Mandaya is refilling each year. Dabus and Beles will continue to provide annual flood flows and their sediment loads to the lower Abbay but in more than half of the years Mandaya does not spill. When Mandaya does spill, peak flood discharges will be much smaller than before and occur from 10 to 60 days later than normal. Some of these spill flows will be very small; others will be larger and occur in a very short time (as Mandaya spillway gates are opened), without the normal preceding build up of the rising limb of the flood hydrograph. By this time, Dabus and Beles' peaks will normally have passed.

Mandaya's turbined flows and occasional spillway flows will be charged with very little sediment. When the Mandaya spillway gates are finally closed after spill events, dry season flows, also with very little sediment, will be much greater than prior to regulation. The operation of Roseires reservoir may adjust Mandaya's releases to some extent.

Changes to river morphology are expected to be initiated by these operations and the change in regime. Mandaya releases will be completely free of bedload and virtually free of medium-sized and coarse suspended sediment.

The current rates of sediment transport are unknown for reasons stated earlier. Whatever estimate is adopted, the reduction in sediment transport will be severe and the river's hydraulic ability to erode its bed and banks will increase. As river structures (such as at Roseires, Sennar and Merowe) and the remaining cataracts on the Main Nile provide artificial and natural controls, the new cycle of channel adjustments may be expected to occur in various reaches with these controls ultimately limiting major changes in the longitude profile.

As found necessary in Egypt, river training works, bank protection and other measures are expected to be needed. Hydraulic geometry and morphological studies will be required to explore the river's potential for changes, especially at key sites where valuable structures and equipment are sited. However, these changes will not be restricted to sites of structures and pumping stations. Changes in channel courses through widening and deepening may affect farming and grazing activities of many along riverbanks.

Such changes are part of the normal behaviour of rivers with low gradients in, for the most part, alluvial channels but the question of compensation for “lost” land or for remedial works, in kind or in monetary terms, appears likely to arise in future.

As mentioned in Chapter 6, these river channel morphology issues require detailed attention in further studies. It is anticipated that a department or section may require to be established in the Ministry of Irrigation and Water Resources, with a budget for this purpose, as has occurred in Egypt because of river morphology adjustments below High Aswan Dam.

7.6.4 Fisheries along Blue Nile and Main Nile

Little quantitative information appears to be available on exploitation of Blue Nile and Main Nile river fisheries (compared with reservoir fisheries and aquaculture).

The substantial changes in hydrology expected in Sudan in Mandaya’s operational phase (Tables 7.4, 7.5 and 7.6) and in river morphology (described above) may be expected to impact on aquatic animals’ life cycles, river fisheries and fishing methods. These impacts are difficult to determine without more detailed studies, including examination of outputs of conjunctive use simulations of Mandaya releases and the Sudan power cascade. These may be anticipated in future studies.

However, it appears probable that fisheries in the main river are under exploited and, if some adjustments to fish catching methods are used in the low flow season (Table 7.6, when Mandaya regulation will raise flows) fish yields may be as they are now or increased.

With regard to Roseires and Sennar reservoirs, significant changes in methods of reservoir operation are expected. With regulation provided and sediment trapped by Mandaya, these reservoirs may be operated at near full supply levels throughout the year, compared to having annual drawdowns each year. This kind of operation is assumed in the energy uplifts in Table 7.9. This implies, *inter alia*, greater water surface areas, with greater light penetration because of reduced sediment loads. This appears likely to be beneficial for aquatic life, including fisheries. With adjustments to fish catching methods, as may be required, it seems probable that primary productivity and fish catches may increase.

A danger to river fisheries between Mandaya and Roseires, and Roseires reservoir fisheries, is related to those relatively rare occasions when Mandaya cannot sustain its normal releases of turbined flows at the end of some dry seasons (Table 7.6) and only prescribed flow releases are made. On these occasions, assuming Roseires is used conjunctively with Mandaya, Roseires reservoir will be drawn down, receiving water from Mandaya which may be of poor water quality.

Thus, attention is drawn again to the Mandaya project improving downstream low flow conditions for most of the time but aggravating conditions in some dry season months. According to simulations, these occur in four or five of the 50 years and so are fairly rare occurrences. The prescribed flows and conjunctive use of these reservoirs is an area that requires much more attention in future studies.

7.6.5 Irrigation along Blue Nile and Main Nile in Sudan

By the same means, the increase in dry season flows from Mandaya tailrace to High Aswan Dam will increase dry season water availability at existing and new offtakes for public water supply and irrigation. Apart from increased water availability, the increased flows will be associated with higher water levels, thereby reducing suction heads (and energy costs) of pumped water supplies.

These benefits are expected to be very substantial. It is known that farmers at the end of existing irrigation systems receive inadequate water supplies currently; their position should be improved. Also, there are likely to exist irrigation command areas that have been abandoned; these may be resuscitated.

It may be noted that when Mandaya reservoir is drawn down and releasing prescribed flow, Roseires reservoir storage may be used to maintain water supplies for irrigation schemes downstream. As mentioned above, the prescribed flows and conjunctive use of these reservoirs is an area that requires attention in future studies.

The areas of existing irrigation which will benefit from improved dry season supplies are shown in Table 7.10. The RAPSO simulation model has provided for the year 2012 demands but not for addition water demands required by intensification of cropping which would be facilitated by Mandaya regulation. According to the Long-Term Agricultural Strategy (2002-2027), the expected increases in Blue Nile and Main Nile cultivated areas are 1,074,000 and 260,000 feddan respectively. These areas should all benefit.

Table 7.10 : Existing and proposed Irrigation

Nile Tributary	Cultivated Area (1,000 feddan)			Water Requirements (Mm^3)		
	2002	2012	Increase	2002	2012	Increase
Blue Nile	2112	3186	1074	9050	11481	2431
Main Nile	311	571	260	1300	1903	603

Source: Long-Term Agricultural Strategy (2002-2027)

Within the 260,000 feddan expansion for the Main Nile, the Ministry has indicated that it has plans for implementation of 121,210 feddan within the foreseeable future. The schemes include Wad Hamid basin 17,000 feddan; Salwa basin 7,000 feddan; Salem 55,210 feddan; Letti 7,000 feddan; Khos Argo 30,000 feddan; and Khor Hadnab 5,000 feddan. It is understood that these areas are currently productive following recession of the annual flood. When converted to irrigation, they will have potential for growing two crops each year.

Quantification of the irrigation benefits will require detailed studies in future.

7.6.6 Reduction in flooding along Blue Nile and Main Nile in Sudan

Review of existing conditions

Chapter 5, Section 5.6, introduced Sudan's flood warning system and its agricultural significance, and estimated that some 866,700 feddan are dependent on the annual flood of the Blue and Main Nile. It remained to be seen how Mandaya hydropower project in Ethiopia would affect the magnitude and frequency of annual flood levels in Sudan.

It was inferred that any reduction in Control Levels for "Flooding" would make a big improvement because big floods have major impacts on health, delay and/or spoil cultivation, seriously spoil communications and cause damage to properties, equipment and flood protection dykes – all incurring heavy costs. On the other hand, because big floods are "a mixed blessing", the full recharging of groundwater and mataras adjacent to the floodplain, supply of siltation as a free "fertilizer", and fish spawning and recruitment would be diminished to some unknown extent if these major floods were reduced. However, on balance, it is concluded that reductions in flooding extent, depth and duration would be overwhelmingly beneficial (SMEC, 2006). In other words, if "Flooding" Control Levels are reduced in frequency, or even stopped altogether, it would be regarded as something very beneficial to livelihoods and the economies of the affected areas.

It was inferred that any reduction in Control Levels for "Critical" – the condition when the flood plain is fully flooded but not flooding properties – would benefit farmers enjoying pumped water supplies for irrigation but would not benefit some of the farmers because the flood and silt would no longer reach their land.

It was inferred that any reduction in Control Levels for "Alert" years, occurring in a little under half of all years and which are good for many farmers but not for all, would cause less crop production and greater food shortages.

It was also noted that "Normal" flood years present crisis conditions (food shortage) because the river does not flow out of its banks, unless an area enjoys pumping facilities for irrigation. 1972 and 1984 were noted to be years common at all station (Table 5.19).

Impacts

A comparison is made in Table 7.11 of the flood conditions from 1988 to 2003. These are the years for which the Ministry has supplied annual maximum flood levels and for which the RAPSO model has simulated 10-day discharges from Mandaya.

In making this comparison, the working assumption is made that the annual (10-day) peaks of Mandaya floods directly contribute to the annual (daily) peaks of floods at Khartoum, Shendi and Dongola. Generally, this seems reasonable but it should be kept in mind that this may not always be so because on some occasions the peaks of Dabus, Beles, Dinder and Rahad may influence the peak of downstream levels and the Atbara may influence the peaks recorded at Dongola gauging station. Detailed hydrograph and flood routing studies would be required to distinguish between these.

Table 7.11 : Impact of Mandaya on Flood Control Levels

Year	Flood level (m) & colour code			Mandaya flow reduction m^3/s	Mandaya Impact on Flood Levels
	Khartoum	Shendi	Dongola		
1988	16.94	18	15.69	3,560	Reduction
1989	16.04	17.07	14.15	3,536	Reduction
1990	15.20	16.5	13.6	3,128	Reduction
1991	16.14	17.22	14.72	3,587	Reduction
1992	16.05	16.98	14.64	3,363	Reduction
1993	16.53	17.59	14.76	3,522	Reduction
1994	16.94	17.96	15.69	1,543	Reduction
1995	15.81	16.97	14.74	2,916	Reduction
1996	16.67	17.72	15.17	2,557	Reduction
1997	15.97	16.85	14.48	2,753	Reduction
1998	17.09	18.01	15.91	2,569	Reduction
1999	16.75	17.84	15.72	2,134	Reduction
2000	16.60	17.93	15.37	4,009	Reduction
2001	16.74	17.85	15.93	1,969	Reduction
2002	15.52	16.42	14.44	2,630	Reduction
2003	16.38	17.4	15.29	3,206	Reduction

Flooding	Critical	Alert	Normal

In the 16 years with gauge height data provided by the Ministry for comparison, Mandaya causes reductions in flooding of greater than 1,500 m^3/s (130 Mm^3/d) on every occasion. These reductions would be beneficial for all “Flooding” conditions at Khartoum, Shendi and Dongola. In the other years, when “Critical” and ”Alert” occurred, the reduction in flood discharges at Mandaya would reduce the spatial extent and duration of flooding and silt deposition.

An indication of the reductions in flood levels for these 16 years may be estimated by reference to river gauging rating curves at Khartoum and Dongola (Table 7.12 and 7.13).

For these 16 years at Khartoum, the average reduction in flood level is 2.80 m (maximum reduction 3.85 m, minimum 1.29 m). In all years, the flood warning system classification of the peak flood falls by one or more categories, as shown by the changes in flood colour codes. With Mandaya regulation, the indications are that there would be no “Flooding“ or “Critical” control levels at Khartoum in this period. All flood levels are reduced to “Normal” or “Alert” (Table 7.12).

Table 7.12 : Changes in Annual Flood Levels at Khartoum

Station	Year	Peak Level Gauge height	Peak Flow	Mandaya Reduction in flow	Reduced Flow at Khartoum	Gauge height for reduced flow	Change in Gauge height at Khartoum
		m	Mm^3/d	Mm^3/d	Mm^3/d	m	m
Khartoum	1988	16.94	564	308	256	13.72	-3.22
	1989	16.04	469	306	163	12.50	-3.54
	1990	15.20	386	270	116	11.77	-3.43
	1991	16.14	479	310	169	12.58	-3.56
	1992	16.05	470	291	179	12.72	-3.33
	1993	16.53	520	304	215	13.21	-3.32
	1994	16.94	564	133	430	15.65	-1.29
	1995	15.81	446	252	194	12.93	-2.88
	1996	16.67	535	221	314	14.41	-2.26
	1997	15.97	462	238	224	13.32	-2.65
	1998	17.09	580	222	358	14.90	-2.19
	1999	16.75	543	184	359	14.91	-1.84
	2000	16.60	527	346	181	12.75	-3.85
	2001	16.74	542	170	372	15.05	-1.69
	2002	15.52	417	227	190	12.87	-2.65
	2003	16.38	504	277	227	13.36	-3.02

Rating curve:

Khartoum: $Q = 20.96\ (G-8.8)^{1.57}$

Where Q is million cubic metres per day, and G is gauge height in metres

Flooding	Critical	Alert	Normal

For these 16 years at Dongola, the average reduction in flood level is 1.58 m (maximum reduction 2.26 m, minimum 0.69 m). In all years, the flood warning system classification of the peak flood falls by one or more categories, as shown by the changes in flood colour codes. With Mandaya regulation, the indications are that there would be no “Flooding“ control levels at Dongola in this period. All flood levels are reduced to lower Control Levels (Table 7.13).

Table 7.13 : Changes in Annual Flood Levels at Dongola

Station	Year	Peak Level Gauge height	Peak Flow	Mandaya Reduction in flow	Reduced Flow at Dongola	Gauge height for reduced flow	Change in Gauge height at Dongola
		m	Mm^3/d	Mm^3/d	Mm^3/d	m	m
Dongola	1988	15.69	845	308	538	14.00	-1.69
	1989	14.15	562	306	257	11.89	-2.26
	1990	13.6	476	270	206	11.39	-2.21
	1991	14.72	660	310	350	12.69	-2.03
	1992	14.64	646	291	355	12.73	-1.91
	1993	14.76	667	304	363	12.79	-1.97
	1994	15.69	845	133	712	15.00	-0.69
	1995	14.74	663	252	411	13.15	-1.59
	1996	15.17	743	221	522	13.90	-1.27
	1997	14.48	618	238	380	12.92	-1.56
	1998	15.91	891	222	669	14.77	-1.14
	1999	15.72	851	184	667	14.76	-0.96
	2000	15.37	781	346	435	13.32	-2.05
	2001	15.93	895	170	725	15.07	-0.86
	2002	14.44	611	227	384	12.95	-1.49
	2003	15.29	766	277	489	13.68	-1.61

Rating curve:

Dongola: $Q = 7.20 (G-6.7)^{2.17}$

Where Q is million cubic metres per day, and G is gauge height in metres

Flooding	Critical	Alert	Normal

The flood hydrology in the calculations that give these results is simplistic and imperfect. Notwithstanding this, the general picture appears clear and may be described as follows:

Impacts on Flooding of Property

Mandaya will relieve "flooding" of properties and this will be very valuable. Substantial savings will be made in the costs of health service provisions and emergency services which are required during and after major floods. Costs of rehabilitation of infrastructure, including roads, bridges and culverts and of maintenance of flood dykes, will be reduced. The analysis is too limited and simple to claim that all "flooding" will cease but there appears to be no doubt that control of the Blue Nile at Mandaya will have major beneficial impacts.

As noted in Section 5.6.1 and in Appendix 5.2, the cost of mitigating flood damages along the Blue and Main Nile for a 100-year flood has been estimated at USD 527 million, and the average annual damage has been estimated at USD 52 million. These estimates do not include all damage costs. It is noted that the average annual damage is derived by integration of costs under the loss/probability curve, from 5-year floods (no damage) up to and beyond the 100-year flood. Thus the average annual damage, estimated at USD 52 million, includes isolated and very rare flood damage costs and will necessarily overestimate the flood alleviation benefits of Mandaya to some extent. This is because, although Mandaya beneficially controls all floods in the 50-year simulation in this report, it cannot be claimed that Mandaya will control and prevent all flood damages in very rare floods. Nevertheless, the estimate of the average annual damage is probably of the right order of magnitude to claim as a multipurpose benefit of the Mandaya project.

Impacts on Recession agriculture and wetlands

With regard to recession agriculture and wetland areas along the Blue and Main Nile, which benefit from “critical” and “alert” floods, Mandaya will reduce the depth, duration and frequency of flooding, and the deposition of silt.

The conclusion on this is that farmers and communities dependent on recession agriculture will be seriously worse off with the Mandaya project. It appears clear that mitigation by pumping water supplies will be required.

As described in Section 7.6.5, there are large areas of irrigation (2,112,000 feddan) in the Blue Nile basin, generally located away from all but fed by the Blue Nile. There are some existing irrigation schemes (311,000 feddan) along the Main Nile. These are within or adjacent to areas with flood recession agriculture. The Long-Term Agricultural Strategy (2002-2027) anticipates additional irrigation schemes being implemented, including an additional 1,074,000 feddan on the Blue Nile and 260,000 feddan on the Main Nile, of which some 121,000 feddan may be implemented in the near or foreseeable future.

It is not clear how much of the Blue Nile irrigation expansion areas currently benefit from the annual flood. However on the Main Nile, at least 121,000 feddan of the irrigation expansion areas are known to currently depend on the annual flood. Once implemented, they will not be dependent on the vagaries of the annual flood and therefore immune from the impacts of flood reductions caused by Mandaya.

There remains an undetermined amount of land which would be affected by reduced flooding caused by Mandaya regulation. In order to obtain an estimate of these areas, the riverside “agricultural areas” derived from remote sensing may be provisionally adopted as gross areas which benefit from the annual flood, and the already mentioned irrigation areas subtracted to provide the estimated balance (Table 7.14).

Table 7.14 : Irrigation Mitigation for Reduced Annual Flood

Nile reaches Ethiopian Mandaya to Lake Nubia	Riverside Agricultural Area feddan	Riverside Area, Assumed Developed irrigation feddan	Balance of area, vulnerable to reduced flooding feddan	Water demand for Converting vulnerable area to irrigation Mm^3/year
Blue Nile	200,700	0	200,700	1260
Main Nile	666,000	432,000	234,000	1722
Total	866,700	432,000	434,700	2,982

Source: Riverside agricultural area, Chapter 5, Table 5.22

For the Blue Nile, the riverside agricultural area determined by remote sensing purposely and definitely excluded Gezira and other irrigation schemes away from the river. The area of 200,700 feddan is the area determined as being supported by the annual flood. It may include some existing irrigated land but certainly not much. The distribution of irrigation expansion land is not known. The table therefore assumes that 200,700 feddan may require mitigation in order to keep this land productive. The water demand is based on delivering 1500 mm per year.

For the Main Nile, the riverside agricultural area determined by remote sensing includes irrigation schemes near the river – all vegetated areas along the river. The area of 666,000 feddan is therefore the area determined as being supported by the annual flood and irrigation. The assumed developed irrigation area (432,000 feddan) is the sum of existing irrigation (260,000 feddan) and the area expected to be implemented in the near or foreseeable future (121,000 feddan). The table therefore assumes that 234,000 feddan may require mitigation in order to keep this land productive. The water demand is based on delivering 1750 mm per year.

The estimated capital and annual energy costs for this mitigation are given in Tables 7.15 and 7.16.

Table 7.15 : Capital Costs for Mitigation of Reduced Annual Flood

Mitigation irrigation area feddan	Planning and implementation cost USD/feddan	Capital cost USD million
434,700	4,000[1]	1,739

Source of costs: Ministry of Irrigation and Water Resources, Khartoum.

Note: [1] Costs include capital cost and annual operational cost for an unknown number of years.

Table 7.16 : Annual Energy Costs for Mitigation of Reduced Annual Flood

Annual Water Pumping	Power required assuming 8 months, 26 d per month, 12 h per day, 5 m head, efficiency 70%	Energy required	Cost USD per MWh	Energy cost per 1,000 Mm^3	Energy cost for pumping 3,000 Mm^3
Mm^3	MW	MWh	USD	USD million	USD million
1,000	8	19,464	50	0.973	2.9

Source: This Study

The energy estimation has made the assumption of using electric pumps. In practice, some areas may not have access to electricity. The annual cost of fuel for diesel pumps would be greater than for electricity.

It may be noted that the energy required for pumping 3,000 Mm^3/year (3 x 19,464 MWh) represents about 0.5 % of the average annual energy generated at Mandaya.

Another way of looking at this is to consider the uplift in energy in the Sudan cascade attributed to Mandaya. The energy required for pumping 3,000 Mm^3/year represents under 3 % of the average annual energy uplift. This provides a useful perspective on the relatively small amount of energy required for pumping water following conversion from flood recession farming to irrigation and obtaining two crops per year.

This electrical energy is equivalent to displacing approximately 40,000 tons of CO_2/year otherwise generated by thermal plant.

Clearly, these indicative cost estimates are crude and dependent on many factors, not least the areas to be converted to irrigation. By taking the areas from remote sensing (866,700 feddan) as an approximation of the area which benefits from annual flooding, before subtracting documented irrigation areas within the alluvial belt (432,000 feddan), the estimates seek to ensure that all areas will remain productive continuously when upstream storage in Ethiopia reduces or curtails annual flooding.

Against these capital and annual development costs, there would be significant benefits arising from improved livelihoods through more regular and greater agricultural production, and savings made in drought relief, health care, flood defence maintenance, property and infrastructure rehabilitation, etc.

The cultural acceptability of this conversion to pumped irrigation to mitigate for reduced annual flooding has not been assessed for this study. However, four points may be made about this here.

- Some 1.5 million people depend on the Main Nile in Sudan for their livelihoods. Although many now utilise irrigation and more will do so when another 121,000 feddan are brought under irrigation, there is a large population dependent on annual flooding. It is inconceivable that a major storage development in Ethiopia could be developed and reduce or curtail annual flooding without mitigation measures such as these.

- The substantial raising of dry season flows by regulation (effectively providing the water of the annual flood throughout the year in the desert) ensures that water supplies will be available for abstraction at all times, and available at a higher river level.

- The irrigation mitigation facilities will provide for two crops per year, compared with one crop from flood recession, the latter being uncertain in some years for some people. The certainty of these regulated water supplies, and the certain potential of getting two crops per year, may more than offset worries about reduced siltation as a fertilizer and the adoption of artificial fertilizers.

- In the medium to long-term future, regulated water supplies will reduce as the reliable yield of the upstream storage reduces owing to progressive siltation. The long-term sustainability of the project therefore remains an important issue not only for power trading but for all stakeholders along the Blue and Main Nile in Sudan. This emphasises again the need for support for ENTRO's developing watershed management programs everywhere, but in this case in Mandaya's Abbay river catchment area.

7.6.7 Reduction of Reservoir Siltation Rates in Sudan and Egypt

Estimates of the mean annual total sediment load (suspended and bed load) of Abbay at Mandaya dam site are very uncertain. The current average annual rate may be 285 Mt/year, and increasing. As noted earlier, Roseires and Sennar reservoirs have lost significant storage capacity (and firm yield) because of siltation and have to be operated in the flood season to minimize further siltation – a practice which is detrimental to power generation in the annual flood season.

Storage of all bed load, and much of the suspended load, in Mandaya reservoir may be expected to benefit operations at Roseires and Sennar, permitting power generation in the portions of the annual flood months when currently power generation ceases or is reduced.

Furthermore, additional future losses in Roseires and Sennar reservoir storage capacity should be reduced (though not curtailed completely – Dabus and Beles sediment loads will continue to arrive). This is expected to maintain their already reduced yields for irrigation supplies in contrast to their yields progressively reducing with additional siltation.

Similar benefits may be expected at Merowe.

Clearly, sediment permanently stored at Mandaya will not reach HAD. The benefits of this at HAD are that more water may be stored in exceptional years (like 1988) than would otherwise be the case with more siltation (reducing Toshka spillway flows to "waste") and preserving/maintaining reservoir yield for a longer period.

Apart from Mandaya reducing reservoir storage losses in Sudan and at HAD, there are other associated benefits. The uplift in energy operations at Roseires, Sennar and Merowe has already been demonstrated. The uplift is in part due to greater regulation but also to permitting better operation throughout the year without having to release heavily silted flows without generating or with reduced generation. Another benefit is related to reduced dredging and turbine-replacement costs.

7.6.8 Reduction of Sediment Loads at Abstraction Locations and Irrigation Canals

Storage of all bed load, and much of the suspended sediment load in Mandaya reservoir may be expected to benefit operations at water supply and irrigation schemes significantly.

The CRA Distributive Analysis draft report (January 2007) presents information on reservoir and irrigation system sedimentation. With regard to abstractions for water supply and irrigation systems in Sudan, it notes that sedimentation leads to

- Reduced agricultural production
- Higher irrigation-system operation and maintenance costs
- Higher costs of water purification
- Pump damage

The report estimates costs of reservoir sedimentation at Roseires and Sennar dams with regard to downstream losses in agricultural production (Table 7.17).

Table 7.17 : Irrigated Crop Production Forgone Caused by Sedimentation of Roseires and Sennar Dams

Dam	Cost (USD million) (1)	Cost (USD million) (2)
Roseires	138	103
Sennar	84	63
Total	316	230

Source : CRA Distributive Analysis draft report (January 2007)

(1) Assumes a reduction in irrigated area and yield; (2) Assumes a reduction in irrigated area

The table shows that sedimentation causes a loss of between USD 230 million and 316 million depending on whether the decline is in the irrigated area or yield or both. These losses are expressed in present values using a 10% discount rate over 20 years.

The CRA Distributive Analysis draft report also refers to increased irrigation system operation and maintenance costs. It reports that in 1991 some 9.78 million m^3 of silt entered the irrigation canal system of the Gezira-Managil scheme of which 62% is deposited in the canals with the remainder being deposited in the fields (World Bank, 2002). Desilting of the 17,244 km of irrigation and 10,650 km of drainage canals in the Gezira scheme alone is an enormous and expensive operation, estimated in 1997-98 to cost USD 5.87 million per year.

The CRA report states that it is estimated that 2.24 million tons/year enter the Rahad and other pump schemes along the Blue Nile. The present value of these costs (assuming the same sedimentation patterns inside all schemes) is shown in Table 7.18. Total present value of these costs is USD 46.26 million.

Table 7.18 : Rahad and Gezira-Managil Irrigation Schemes - Estimated Present Value of Sediment and Weed Clearing Costs

Scheme	NPV USD million
Gezira-Managil	36.00
Rahad	10.26
Total	46.26

Source : CRA Distributive Analysis draft report (January 2007)

High sediment loads in the Blue Nile also cause problems for domestic and industrial water supply abstractions and water treatment plants, incurring additional costs.

Thus, reduced sediment loads below Mandaya will benefit many users of the river.

7.6.9 Reduction of Sediment Loads and Use of Artificial Fertilizers

Storage of much of the Abbay's suspended sediment load in Mandaya reservoir may be expected to benefit operations of Roseires, Sennar and Merowe and at water supply and irrigation schemes significantly, as described, with substantial savings in maintenance costs. Not least, sedimentation of Mandaya reservoir will extend the life of High Aswan Dam.

However, the reduction in suspended sediment loads will be noticed by farmers in the estimated 866,700 feddan (determined by remote sensing) along the Blue and Main Nile which currently receive the annual flood and its sediment load. The deposition of silt is regarded as a beneficial and "free" dressing of fertilizer.

The Ministry of Irrigation and Water Resources in Khartoum has pointed out that a study by Nixon (2004) and Abu Zeid (2004) in Egypt has estimated that one ton of sediment is approximately equivalent to 29 kg of artificial fertilizer. According to the sediment budget described in Chapter 4 (Table 4.10), some 37.41 million tons are deposited along the Blue Nile and Main Nile (Table 7.19).

Table 7.19 : Estimated Sediment Deposition along Blue and Main Nile

Location of Sedimentation in irrigation schemes and in river bed and alluvial plains downstream of Mandaya (excluding reservoirs)	Annual Sediment deposition in million tons/year
Blue Nile Rahad and pump schemes	2.24
River bed and alluvial plains, upstream of Sennar	1.46
Gezira/managil irrigation scheme	7.88
River bed and alluvial plains, downstream of Rahad/Dinder confluence	6.32
Main Nile River bed and alluvial plains, Khartoum to Atbara	4.13
River bed and alluvial plains, Atbara to Merowe	6.30
River bed and alluvial plains, downstream of Merowe to Lake Nubia	9.08
Total	37.41

Source: Table 4.11

It may be noted that this sediment budget includes bedload (of no use as a fertilizer) and does not, and cannot, distinguish between deposition in “river bed” and “alluvial plains” – it necessarily groups this deposition together. It is the reduction in deposition in the alluvial plains component, where one ton may be approximately equivalent to 29 kg of artificial fertilizer, which will be noticed by farmers.

There are many points to be noted.

- Firstly, the sediment budget almost certainly underestimates sediment inflows for current catchment land use conditions.
- Secondly, the silt deposition enjoyed by farmers in Sudan (and formerly in Egypt) for millennia, is now considered to be at an accelerated rate because of lack of comprehensive and effective watershed management measures in the Abbay basin. The rates of siltation on farmlands are almost certainly greater than required for successful cropping.
- Thirdly, much of the (unsettled) clay fraction and a little of the (unsettled) fine silt of Mandaya’s sediment load will continue to arrive downstream.
- The Dabus, Beles, Rahad and Dinder sediment loads will continue. They may be increasing.
- The Atbara’s sediment load will continue. It will be reduced by storage development at Tekeze but the CRA report on Ethiopia/Sudan indicates that

there is accelerated erosion in the catchment area. This may also be increasing.

- Finally, river morphology changes expected downstream of Mandaya may be expected to re-mobilize and entrain bed and bank sediments in some alluvial reaches during spillway flood flows and at other times, and therefore contribute some sediment load from this source.

This is a very complex area – a component of the “mixed blessing” of the annual flood – requiring greater study. However, on balance, the conversion from annual flood recession agriculture (with all the uncertainties and difficulties associated with it) to pumped irrigation (with the guaranteed certainty of sufficient water supplies for two seasons of cropping each year, though with reduced siltation on farmlands) appears likely to be beneficial to most riparian stakeholders.

This was the position taken in Egypt when promoting High Aswan Dam. Notwithstanding and underestimating some difficulties and the need to import some foodstuffs, the control of Nile flows has provided flood control, water supply security and food supply security in Egypt for a growing population very successfully and the heavily reduced siltation on farmlands has been accommodated.

7.6.10 River Crossings of Blue Nile

Mandaya’s river regulation will substantially increase flows in dry seasons. The impacts of this are not likely to be unmanageable for ferryboats and fishermen who are accustomed to operating at higher river levels than the regulated flows in the dry season. Mandaya power generation operations will be as for a baseload station, not peaking, and so abrupt daily fluctuations in river level are not expected. If this concept should change in future, a detailed boat /navigation survey will be required to assess impacts in detail and mitigating measures, and to consider extension of the flood warning system to all riparian users, not only for ferrymen and other boat users.

In the cultural assessment of the Blue Nile in Chapter 5, mention was made of groups who at times live close to the Blue Nile. These groups and their livestock may cross the river by wading in the dry season. There are the Rufa’a al-Hoi people with sheep, cattle and camels - one group located on the Blue Nile in the dry season before moving north towards the Dinder River for the wet season, and the southern Badiya who used to move between the Yabus (in the dry season) and the Gezira/Managil schemes (in the wet season). There are the Kenana pastoralists who move between the Blue Nile northwards beyond the Dinder River. Also, the Fulani follow the same transhumant patterns as the Rufa’a al-Hoi but at slightly different times usually leaving the dry season grazing area later. Also, many Ingessana work as herders for the Rufa’a al-Hoi people. All of these groups, and others, may cross the river from time to time.

Fieldwork has not been carried out to confirm that any of the above groups, or any others, cross the Blue Nile towards the end of the dry season by wading. Thus, the concern expressed here is completely speculative and will need confirmation by those who know and by field inspection in the dry season, or otherwise.

An illustration of the change in Abbay river levels below Mandaya is made by reference to the rating curve for El Deim river gauging station, as if the rating were transposed and applicable to the river below Mandaya dam site, before Dabus and Beles tributary discharges are received (Table 7.20). This indicates that levels will increase by some 1.43 m and 1.70 m in January and April respectively, compared to long-term average conditions. (The transposition of the El Deim rating in this way is not good practice but the indicated changes in levels are probably reasonable for present purposes). Where a man can just wade across the river in safety at a favourable site will become impossible with such increases.

Table 7.20 : Increase in Abbay/Blue Nile's Dry Season River Level with Mandaya Regulation

Dry Season Month	Mean natural flow at Mandaya	Natural river level at Mandaya	Regulated Mean Flow at Mandaya	Regulated river level at Mandaya	Increase in river level
	m^3/s	m	m^3/s	m	m
January	171	6.73	872	8.16	1.43
April	110	6.48	880	8.18	1.70
Rating curve: El Deim: $Q= 6.419 (G-5.3)^{2.34}$ Where Q is million cubic metres per day, and G is gauge height in metres (NB. Flow in table is in m^3/s).					

For people on foot, therefore, river regulation may present a serious problem. It is not only pastoralists who may be adversely affected but all kinds of people who traditionally cross the river in the dry season for market, wedding and other ceremonies.

Further study is required to assess the practical and safety issues of raising dry season flows for all riparian users, including boat users and people on foot. Mitigation measures may include provision of additional ferryboats. Care will be required to provide safe bank side conditions for ferry services.

7.6.11 Evaporation and water supplies from High Aswan Dam

Mean annual evaporation at High Aswan Dam (HAD) has been historically estimated at 10 billion m^3/year (Nile Waters Agreement, 1959). This is equivalent to evaporating all the flow of a river with a mean annual flow of 317 m^3/s. A saving in evaporation losses at Aswan of 1.0 billion m^3/year, equivalent to a continuous flow of approximately 31.7 m^3/s, would provide an additional supply for Egypt and Sudan equivalent to irrigation of some 50,000 to 60,000 feddan throughout the year, depending on crops and cropping patterns. Some have suggested that half of Aswan's evaporation losses, 5.0 billion m^3/year (158 m^3/s) might be saved by operating Lake Nasser/Nubia at lower levels but the development scenarios leading to this estimate in saved losses have not been seen during this study.

Although simulation of Mandaya reservoir behaviour shows that some 0.58 m^3/year (18.4 m^3/s) evaporation losses would occur at Mandaya and therefore reduce flows in the Nile system, this would be more than offset by operating Lake Nasser/Nubia at a lower level on average. This can occur because of Mandaya reservoir releasing water to HAD more evenly than occurs naturally – and not requiring re-regulation by storage at Aswan – and by holding water in storage at Mandaya with a lower evaporation rate and a relatively small reservoir surface area.

Table 7.21 provides some comparative data for Mandaya and HAD.

Table 7.21 : Comparison of Evaporation Losses at Mandaya and High Aswan Dam

Reservoir	Res Level masl	Res Surface Area km^2	Indicative evaporation rate m/year	Indicative evaporation at constant level, for comparison purposes only BCM/year	Indicative reduction in losses at HAD BCM/year	Evaporation from simulation of Mandaya[1] and adopting 10 BCM at Aswan BCM/year
Mandaya FSL	800	736	0.838	0.62	-	0.58
HAD at FSL	175	5,168	say, 2.5	12.92	0	10
HAD	170	4,308	say, 2.5	10.77	2.15	10
HAD	165	3,581	say, 2.5	8.95	1.82	10
HAD at FSL/ Mandaya	-	x 7	x 3	x 20.8	-	x 17.2

Note[1] Evaporation from 1800 No. 10-day periods in 50 years RAPSO simulation (this study)

At FSL, Lake Nasser/Nubia has a surface area seven times larger than Mandaya. The mean annual evaporation rate in the Nubian Desert is about three times greater than the net evaporation rate at Mandaya. Thus, at FSLs, for every cubic metre evaporated at Mandaya, Lake Nasser/Nubia loses about 21 cubic metres.

This potential trade-off in evaporation losses, although at the expense of some reduction in energy generation at HAD, is considered to be very significant. By operating HAD with a smaller surface area (i.e. at a lower level), evaporation losses may be converted into usable water supplies from the Main Nile, offering greater food security for an increasing population in Sudan and Egypt.

This potential gain in water yield is offset by a loss in energy generation because reduced Lake Nasser/Nubia levels provide reduced head for generation. The balance of water supply benefits and energy losses requires much greater investigation in future.

7.6.12 Lake Nasser/Nubia - Fisheries, Agriculture and Navigation

In the parallel pre-feasibility engineering study of Mandaya, results of RAPSO model simulations are described in connection with estimating impacts of first filling Mandaya. A summary of these simulations has been given in Chapter 6 where falls of Lake Nasser/Nubia levels of 7, 12 and 18 m were described, depending on the inflow sequence when first filling takes place. The first filling impacts on fisheries, agriculture, settlements navigation, employment and the economy around Lake Nasser/Nubia have been described in Chapter 6.

In order to consider socio-economic impacts around Lake Nasser/Nubia in the operational period, after first filling at Mandaya, it is helpful to consider a 50-year simulation of the system.

Figure 7.5 presents the hydrograph of Lake Nasser's levels, inflows and discharges for a particular case. In this simulation, the first filling of Mandaya begins in 1954 (beginning a relatively wet sequence) and the 7 m fall in Lake Nasser/Nubia level occurs in 1956 and again in 1958. Thereafter, the lake recovers fairly rapidly and maintains higher levels until the dry sequence occurs in the 1980s when the lake operates at generally low levels for more than 10 years before recovering again. This run produced an average reduction in energy generation at High Aswan over the 50-year simulation period due to the reservoir filling and operation of the Mandaya project of 202 GWh/year, for which it was noted that the reduction in generation was greater in the early years.

It should be noted that the reduced levels at Lake Nasser/Nubia in the 1950s, caused by first filling of Mandaya, were nowhere near as severe as the levels produced in the 1980s, caused by natural drought conditions. Lake Nasser/Nubia maintained its water supply yield downstream throughout the 50-year simulation – benefiting from Mandaya's regulation. However, there is no doubt that the prolonged period of sustained low levels in the 1980s ending in 1998 (when rapid recovery occurs) is in part due to Mandaya filling following the 1980s drought – not Mandaya's first filling but Mandaya's re-filling. This may in part be illustrated by returning to Table 7.4 and Figure 7.2 and noting a long sequence of years at Mandaya where the maximum downstream 10-day releases in 14 Augusts were at the prescribed minimum flow of 1,000 m^3/s for August (1979 to 1993, excepting 1988 when some spill occurred at Mandaya).

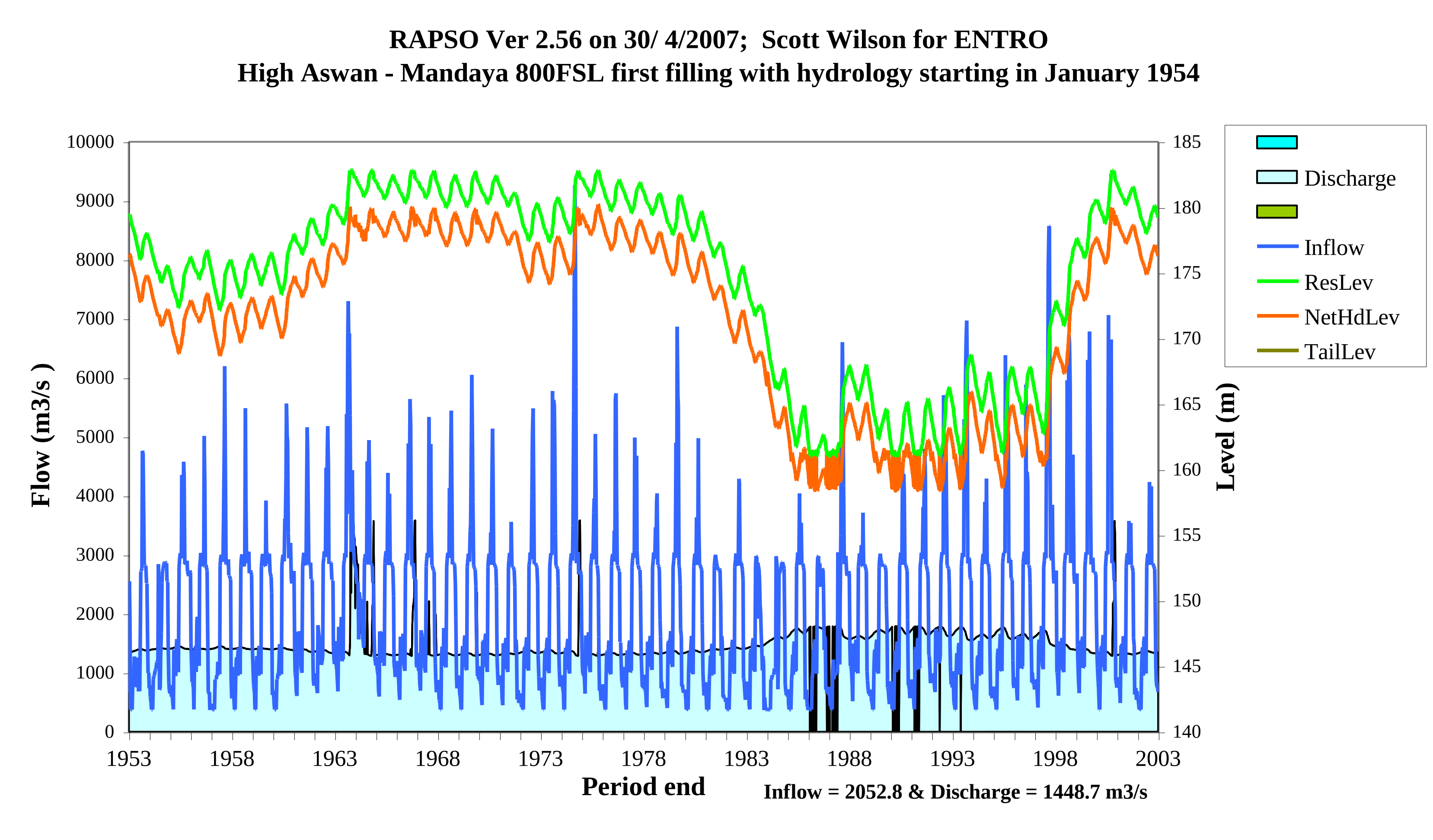


Figure 7.5 : Aswan 50-year Operation with Mandaya filling from January 1954

This therefore draws attention to the point that Mandaya, having filled and become fully operational, will necessarily cause Lake Nasser/Nubia to operate at lower levels following a major drought for a longer period than would be the case without Mandaya. It is suggested that the socio-economic impacts of this are, or may be very mixed:

- fisheries production may be reduced for a longer period because of the continuing smaller reservoir habitat for primary production and fish life, or maintained because the catch per unit effort increases with the greater concentration of fish;
- energy costs for pumped irrigation supplies for farming areas around the lake located above normal full supply level will increase because of the longer duration of low lake levels
- energy costs at Mubarak pumping station (if operating) will increase for similar reasons
- navigation will continue in this prolonged low level period in a similar manner to navigation during the preceding natural drought levels, without additional burden

There is an interesting and important feature of this particular simulation sequence. The prolonged period of low levels (and low storage contents) at Lake Nasser/Nubia until 1998 made it possible for the lake to store the very high flows in 1998 and 1999. It was noted in Chapter 5 that the Toshka spillway discharged some 12.4 billion m^3 and 16 billion m^3 in these years. The impact of Mandaya prolonging the low levels in Lake Nasser/Nubia appears to be that some 28.4 billion m^3 would be retained in the lake and not spill. By retaining this water for use at Aswan power station and downstream, the system would “recover” some of the otherwise foregone energy generation at Aswan.

It is noted that only a sample of simulation runs has been carried out and reported in the pre-feasibility engineering report and that these have adopted particular characteristics. Now that many of the issues relating to Mandaya and Lake Nasser/Nubia operations have been exposed by a few simulations, future studies will need to be much more detailed, using agreed data sets and operating rules, and present matrices of results for many permutations. Three of the issues relating to “agreed data sets” are, for example, the estimated elevation/capacity/area relationship for Lake Nasser/Nubia for present levels of sedimentation, monthly lake evaporation rates, and water demands in the Nile system for given years in future.

On the environmental side, outputs will need to explicitly present data sets and graphics of reservoir water balances, levels and surface areas so that fisheries, irrigation and navigation impacts may be better assessed and compared.

Further, these matrices/permutations should be repeated using other criteria (e.g. changes in FSL and MOL at Mandaya and therefore changes in gross, live and dead storage capacities at Mandaya; changes in prescribed minimum releases at Mandaya) in order to explore improvements in the design of Mandaya.

In addition, the above many cases should be repeated adopting revised storage contents for Mandaya and Lake Nasser/Nubia, where the revisions provide for inevitable loss of storage due to reservoir sedimentation.

Furthermore, these many cases need to be compared with simulation outputs for Lake Nasser/Nubia operating without Mandaya and making assumptions about future sedimentation rates with and without implementation of watershed management practices in the Blue Nile and Atbara sub-basins. In other words, to make comparisons of Aswan's decreasing energy and downstream regulation releases so that the benefits of different levels of achieved watershed management practices may be assessed in Egypt, with and without Mandaya.

7.7 SUMMARY OF MANDAYA'S PRINCIPAL IMPACTS AND MITIGATIONS

The major impacts of the Mandaya project described in Chapters 6 and 7 are summarised in Table 7.22.

Table 7.22: Summary of principal project impacts of Mandaya project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Ethiopia			
Mandaya project	Mandaya power generation, a major national energy benefit and increase in foreign exchange earnings	Involuntary resettlement	Resettlement and development program
Mandaya project	Construction employment, new skills for the future	Loss of wildlife habitat and wildlife	New reservoir wetland and management of environmental offset(s)
Mandaya project	New roads, Abbay bridge, promoting regional development	Loss of natural resources	Development of reservoir fisheries
Mandaya project	Extension of rural electrification	Reservoir sedimentation reducing yield and sales	Implementation of watershed management practices
Sudan			
Regulated flows and reduced sediment	Uplift of energy at Roseires, Sennar and Merowe	River morphology changes	River training works
Regulated flows	Additional irrigation		
Regulated flows and higher dry season river levels	Reduction in energy costs for pumping for irrigation		
Reduced sediment	Reduction in dredging costs at Roseires		

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Reduced sediment, e.g. at Rahad and Gezira-Managil	Reduction in irrigation canal and drainage canal desilting maintenance costs		
Reduced sediment	Reduction in water supply treatment costs		
Reduced sediment	Reduction in pump replacement costs		
Regulated flows and reduced sediment	Incremental fisheries production		
Regulated flows, higher in dry season	Navigation	Higher Blue Nile river levels in dry season	Facilitate river crossings for pedestrians and livestock, or compensation
Reduction in flooding	Reductions in health problems, urban flooding, property flooding, and infrastructure maintenance	Reduction in flooding	Conversion of flood recession agriculture to irrigation, and two crops per year
		Reduction in sediment	Application of artificial fertilizers
Egypt			
Reduced sediment	Extension in life of High Aswan Dam		
Opportunity to operate High Aswan Dam at lower level	Reduction in evaporation losses and conversion to usable water supply yield	Opportunity to operate High Aswan Dam at lower level	Reduction in evaporation losses and conversion to usable water supply yield may more than offset reduction in power generation
Opportunity to avoid/reduce spillage e.g. 1998/99	Increased energy output at Aswan; increased yield downstream	Reduction in Lake Nasser level Less energy at Aswan and Socio-economic (fisheries, agriculture, navigation) around lake	Compensation, or negotiate tariff for importing Mandaya energy to compensate for foregone energy at Aswan Various, to be determined, and/or compensation
Regional			
Mandaya project	Carbon emissions savings of some 424 million tonnes compared with equivalent thermal generation		

8. PROJECT ALTERNATIVES

8.1 PROJECT LOCATION

There are additional and alternative hydropower sites upstream of Mandaya at Mabil, Beko Abo and Karadobi, and at Border downstream. Mandaya's development could be postponed in favour of one or more of these. In the long term, Mandaya's site is so attractive for hydropower development that it will almost certainly be required in cascade with developments at Border, Beko Abo and Karadobi.

8.2 DAM ALIGNMENT

Within the Mandaya dam site area, the topography and geology offer no alternative alignments. The dam alignment has been selected to be on sound foundations.

8.3 FULL SUPPLY LEVEL

The Full Supply Level (800 masl) is at or close to the maximum possible for the site and achieves a very high degree of river regulation. Higher levels are possible but would require a much more costly development without achieving a commensurate increase in benefits.

A lower FSL is possible. It would provide a smaller storage capacity, less firm energy generation at Mandaya, a smaller uplift of energy at downstream stations and a smaller uplift in dry season flows in Sudan. Major benefits in Sudan would be decreased. A lower FSL would provide less protection against reservoir siltation. On the other hand, involuntary resettlement might be reduced and impacts on the annual flood and recession agriculture in Sudan would be reduced.

8.4 MINIMUM OPERATING LEVEL

There are alternatives to the Minimum Operating Level of 760 masl. It could be higher or lower but would have to be within a sensible range (currently 40 m) for power generation for technical reasons. Optimisation studies are required in a feasibility study.

8.5 PRESCRIBED FLOWS

The adopted prescribed monthly flows were selected to ensure Roseires and Sennar can operate in tandem with Mandaya. They have not been optimised.

Explicit conjunctive use studies of Mandaya with these downstream reservoirs are required in future. These should ensure that Roseires could satisfy downstream irrigation demands by drawing on its own storage on those relatively rare occasions when Mandaya releases its prescribed low flows. There are many issues to be considered, including selection of MOL, the 98% reliability criterion's suitability for downstream water supply and irrigation demands, forecasting next year's dry season inflows from, say, October's flows by recession curve analysis, irrigation cropping seasons and their seasonal water demands.

8.6 INVOLUNTARY RESETTLEMENT

Resettlement, estimated at about 600 people in the reservoir area and up to 1,020 in works areas is an important aspect of the project. Our estimates are satisfactory for scoping purposes at pre-feasibility level but cannot begin to be considered as robust. The numbers take no account of population growth in future. Detailed surveys are required, and these will benefit from improved topographic mapping. The significance of a change in FSL, by say 5, 10 or 15 m, cannot currently be assessed.

The overriding impression of the consulting team was that resettlement, properly conducted according to Ethiopia’s federal policies and World Bank safeguards, would result in greatly improved livelihood conditions. The fact that the regional government is already planning resettlement schemes in the area, to reduce geographical dispersion and improve services, is a somewhat unusual situation and one which supports the project concept – subject of course to all the required safeguards being thoroughly investigated and implemented.

8.7 ENVIRONMENTAL OFFSETS

The Dabus Valley controlled hunting area has been suggested as a possibly suitable area as an offset for the loss of a vast area of habitat in Mandaya reservoir. The philosophy behind adopting Dabus as an offset is not to create new habitat – it already exists – but to provide contributions to a management plan for it, following detailed surveys that have been recommended. There appear to be no other candidates close to the impact area suitable as alternative offsets, certainly none with protected area status like Dabus Valley controlled hunting area. However, stakeholders will require a thorough examination of other possibilities because environmental offsets do not necessarily need to be in close proximity to the project causing habitat loss.

8.8 TRANSMISSION LINE ROUTES

The preliminarily selected routes (Mandaya to Hasaheisa/Rabak, 650 km; and Mandaya to Sululta, 450 km or to Debre Markos, 240 km) are nearly the shortest routes between Mandaya switchyard and sites that provide connection with national grids. The routes have been considered at desk level but, apart from in the Mandaya area itself, not in the field. The routes require thorough studies and may require adjusting. A point about the construction track for the Mandaya to Damazin section of the Mandaya to Sudan route is made below.

8.9 CONSTRUCTION ROADS

The project proposes that construction traffic will use the road route from Mendi to Koncho to get access to the Mandaya site on the left bank of Abbay river. Access road works entail upgrading some 20 km of existing metalled road and the construction of approximately 75 km of new roads in mountainous terrain between Mendi and Mandaya. Approximately 22 km of the new road is routed along the line of an existing drivable track and the remaining 52 km is currently inaccessible to motor vehicles. The roads works include seven new Baily bridge type river crossings.

There are no roads on the right bank side of Abbay river which would reduce the amount of road construction to the Mandaya site.

In the early part of construction, a bridge across Abbay will be constructed downstream of the dam site. This may have immense regional significance once constructed, leading to better integration of the Benishangul Gumuz Region but this depends on a new road being constructed from the new Abbay bridge north-eastwards to connect with the existing road network at Wonbera (Debre Zeyit). Currently, this road link is not part of the Mandaya project concept. Consideration should be given to constructing this link road during the project construction period as a project enhancement measure for the region. The financing of this road could be included in the project's road construction contract or arranged otherwise.

8.10 ETHIOPIA-SUDAN ROAD LINK

The report has drawn attention to the desirability of a future road link between Mandaya and Roseires hydropower projects. This road link is not required for Mandaya project construction purposes but is considered desirable for local management and coordination of various surveys between Mandaya and Roseires hydropower projects. This recognises that Mandaya would be at the head of Sudan's existing and developing hydropower cascade. Apart from coordination of hydropower matters (turbined releases, spillway releases, prescribed flows, dam safety, river morphology changes, riparian safety issues, etc), this link may facilitate trade and later regional tourism of a "Blue Nile circuit".

As a construction track will be required for sections of the Mandaya-Hasaheisa/Rabak transmission line, consideration should be given to this construction track being developed as a serviceable road for other traffic and it serving as a link road for wider management and coordination purposes described above.

8.11 WATERSHED MANAGEMENT

There is no alternative to implementing the developing watershed management proposals for the Abbay basin. It appears inconceivable that Mandaya project can proceed without prior and continuing implementation of sustainable watershed management proposals.

8.12 "DO NOTHING" SCENARIO

If Mandaya is not developed, it will play no part in promoting power trade between Ethiopia, Sudan and Egypt. Alternatives are available, as discussed above.

9. ENVIRONMENTAL MANAGEMENT

9.1 INTRODUCTION

Environmental management of a project is concerned with implementation of the measures necessary to minimize or offset adverse impacts and to enhance beneficial impacts. In order to be effective, environmental management must be fully integrated with the overall project management effort at all levels, which itself should be aimed at providing a high level of quality control, leading to a project which has been properly designed, constructed and functions efficiently throughout its life.

This chapter therefore introduces the role of Environmental Management Plans (EMPs) in project development and implementation and introduces the probable overall institutional arrangement for project ownership and management, including management of the EMP as one component of the project. The draft, or pro-type, EMP for the project is then introduced for each country, with comments on the institutional strengthening which will be required.

After introducing the need for and role of an Independent Panel of Experts for the Environment and Community Protection, and commenting about project risks, the requirements and components of a Resettlement Action Plan are introduced. Whilst this is principally couched in terms of resettlement related to the hydropower site and reservoir, many of the elements will be applicable to transmission lines, but on a very much smaller scale, along some reaches where settlements cannot be avoided by selection of routes. The section on RAP concludes with a description of grievance handling procedures.

9.2 ENVIRONMENTAL MANAGEMENT PLANS - GENERAL

Proponents develop environment management plans during a project's planning and design phases in order to promote self-regulation and integration of environmental management issues. The project owner takes primary responsibility for protection of the environment that may be affected by the project and this responsibility may be expressed as commitments set out in the prepared EMP. The EMP may specify all affected environmental values, all potential impacts on environmental values, mitigation strategies and relevant monitoring together with appropriate indicators and performance criteria, reporting requirements and, if an undesirable impact or unforeseen level of impact occurs, the appropriate corrective actions available.

The EMP relates to the various stages of planning for a proposal including development assessment in the pre-construction phase, and in construction and operational phases. It provides a summary of likely environmental impacts, how they will be managed and the responsible implementing and supervisory agencies.

A detailed EMP will be prepared during the project feasibility study. At that time, Site Investigations and engineering studies will firm up proposals and give much clearer definition of the project's impact areas. The future detailed EMP should include the following components: -

- Establishment of agreed **performance criteria and objectives** in relation to environmental and social impacts. These should include measurable indicators and standards;
- Detailed **prevention, minimization and mitigation strategies or action programs (including design standards)** for controlling environmental impacts at specific sites;
- Details of the proposed **monitoring** of the effectiveness of remedial measures against the agreed performance criteria in consultation with relevant government agencies and the community;
- Details of implementation **responsibilities** for environmental management;
- **Timing** (milestones) of environmental management initiatives;
- Reporting requirements and auditing **responsibilities** for meeting environmental performance objectives;
- **Corrective action** (as options) to rectify any deviation from performance standards.

This initial assessment of the pre-feasibility engineering proposals has indicated many impacts of project implementation and various mitigation measures in Chapters 6 and 7. These are brought together in a draft consolidated EMP in following sections. The project's draft EMP is very large because the hydropower project is sited at the upstream end of an existing hydropower cascade on a very long river system and the environmental protection and enhancement measures are many. For ease of presentation to stakeholders in three countries, it is presented as three tables, one for each country: Table 9.1 for Ethiopia, Table 9.2 for Sudan and Table 9.3 for Egypt. They are introduced in subsequent sections where the text and EMPs summarise the project's envisaged institutional arrangements and national responsibilities for environmental management.

In each country's case, the EMP tables proceed through pre-construction, construction and operational phases.

As the EMP table footnotes state, columns to indicate impact and mitigation locations, timing and costs should be added to this table for the project EMP at feasibility stage.

9.3 INSTITUTIONAL RESPONSIBILITIES FOR ENVIRONMENTAL MANAGEMENT

Effective environmental management will be achieved only if it is undertaken as a fully integrated part of the overall project management. In order to effectively implement a comprehensive environmental management plan, coordination of efforts of various agencies is necessary.

At a subsequent stage in the planning process and before financial close, it may be assumed that the project proponent in planning stages (currently ENTRO) will hand over, though still retaining great interest, to a project Owner. It is too early to envisage the composition of the project Owner at this stage of planning but a working assumption may be made that the governments of Ethiopia, Sudan and Egypt will all be represented in the ownership of this major project on an international waterway. It may also be expected that one or more private investors will be shareholders along with the governments of Ethiopia, Sudan and Egypt. This is the model of the Nam Theun 2 in Laos, being developed on a tributary of the Mekong river which drains six countries, and where the project involves power trading between Laos (power exporter) and Thailand (power importer).

The ownership of the project will be determined and approved by the Eastern Nile Council of Ministers (ENCOM) which comprises the water resources ministries of Ethiopia, Sudan and Egypt. ENCOM is charged with the responsibility of overseeing implementation of all projects and programs under the Eastern Nile Subsidiary Action Program (ENSAP).

9.4 ENVIRONMENT MANAGEMENT PLAN FOR MANDAYA

9.4.1 Responsibilities for Environmental Management in Ethiopia

A draft EMP for works in Ethiopia is presented in Table 9.1. It covers the hydropower project and transmission lines and associated works areas.

The overall responsibility for the day-to-day coordination and administration of the implementation of the environmental and social management and monitoring plans set out in the EIA and RAP for activities in Ethiopia, when developed at feasibility level, will lie with the project Owner. It is envisaged that an Environmental Management Unit (EMU) and a Resettlement Management Unit (RMU) will be established by the project to assist the project Owner in Ethiopia.

The project proponent will be responsible, following feasibility studies, for submitting the EIA report, with its EMP and RAP plans, to the EPA and other competent authorities for evaluation according to internal procedures in Ethiopia. The EIA report, with its overall management and monitoring plans, will also be submitted to competent authorities in Sudan (Section 9.4.4) and Egypt (Section 9.4.8).

The project Owner will compile “the Owner’s requirements” in consultation with stakeholders including the federal and regional EPAs in Ethiopia and lenders of finance for the project. These will cover, *inter alia*, environmental protection measures presented in the project’s EMP. The Owner’s requirements are made known in tender documents and contractors are required in their bids to demonstrate their social and environmental awareness and capability in meeting the Owner’s requirements. Once contracts are awarded, environmental management (protection) and monitoring plans will be prepared by contractors, in accordance with the project’s EMP, for approval of the Owner. These contractor’s plans responding to the Owner’s EMP will be site specific, updated and reported on regularly by contractors.

The multinational composition of the Owner will ensure procedures are instituted to maintain a flow of information to respective countries.

The Owner will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up trust and confidence about the project. Regarding environment, the Owner will use his public relations procedures and communications to make known details of the project and its time schedule, impacts and mitigation measures, and grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement. Care will be taken to present information in languages that are understood by stakeholders, and by all conceivable means in order to reach all concerned effectively.

Opportunities for misinformation and misunderstanding are many during the pre-construction activities and the longer period of construction activities. The project Owner will make every effort to avoid these by establishing and using vigorously a first class public relations and communications system.

Among the many issues to be made widely known are those relating to compensation and mitigation measures, the schedule of phased movements required in the RAP plan, dam safety and the downstream flow release regime during the early years of construction, during first-filling of the reservoir and during the project operational phase. It is noted here that all of these and other matters will have been sorted out and agreed in pre-financial closure stages of planning; if they are not, it may be assumed that there will not be finance for the project. The RAP plan for the project's reservoir and works areas is outlined in Section 9.7

The EMU will assist the project Owner in monitoring progress of the contractor's works and environmental protection measures but also in coordinating implementation of the project's EMP for other activities outside of the contractor's responsibilities. In addition to the EMU, it is anticipated that the project's RMU will assist the project Owner in managing and monitoring RAP, along with regional government officers, and ensuring that (phased) resettlement will be achieved according to dates in the program prescribed in the RAP.

With regard to construction of project transmission lines and related works in Ethiopia, it is expected that contractors will carry out these works for EEPCO, on behalf of the project Owner, with arrangements for compensation, resettlement (as may be needed) and monitoring being made by EEPCO and EEPCO's already existing EMU, following procedures outlined in EEPCO's environmental and social management framework (EEPCO, 2007).

9.4.2 Occupational Health and Safety in Ethiopia

General

Health and safety are paramount issues for dam owners and construction contractors. The Owner's requirements, among other requirements, will therefore require the contractor and his subcontractors to ensure that the workplace is a healthy and safe working environment and that public safety is safeguarded within the construction areas with respect to the works. The contractor shall provide all necessary staff, resources and materials to provide for health and safety in accordance with a Health and Safety Plan of the Conditions of Contract and other provisions of the Contract and all applicable laws.

Without in any way limiting the generality of the foregoing, the contractor shall, in respect of all activities in connection with execution of the Works:

a) develop all appropriate measures to be taken to control dangerous goods and prevent industrial accidents;

b) provide medical services adequate to deal with the medical needs of the contractor's and Owner's personnel, including accompanying families, at all times on the construction areas ;

c) install and develop appropriate fire protection, monitoring and prevention services;

d) ensure that any temporary works comply with the Environmental Management Plan and all applicable laws;

e) implement health and safety measures in respect of the buildings and adjacent areas, including offices, workshops, factories, security posts, workers' shelters, schools, accommodation blocks and houses, canteens, messes and restaurants, recreation facilities, markets and retail stores;

f) construct and maintain facilities for water supply treatment and reticulation, and sewage collection and treatment that comply with applicable laws and applicable WHO requirements;

g) provide for the collection and disposal of household commercial and industrial garbage and by-products, including used oils and hydrocarbons, that complies with the applicable laws and the Environmental Management Plan;

h) provide effective storm water collection and disposal systems for all work and accommodation sites, with open areas sufficiently well graded and drained to prevent ponding.

Health and Safety Plan

The contractor shall provide a comprehensive Health and Safety Plan to be submitted to the Owner for non-objection at a prescribed time (e.g. 3 months before construction begins).

The primary purpose of the Health and Safety Plan is to establish a process to preserve the health of all personnel and prevent any accidents that may injure personnel or damage property within the construction areas. The Health and Safety Plan shall be based on a recognized International Standard, such as those issued by the International Labour Organisation

(http://www.ilo.org/public/english/protection/safework/standard.htm).

The Health and Safety Plan shall include:

- guidelines to be followed by the Owner, contractor, sub-contractors and other contractors and their personnel working at the construction areas;
- guidelines and safety rules to be followed by authorized visitors to the construction areas;
- the organization structure and reporting lines in respect of health and safety involving the Owner, the contractor, sub-contractors and other contractors;
- detailed description of the responsibilities, roles, authorities and functions of the Site Safety Officer and the Safety Committee;
- emergency procedures and plans for responding to health and safety emergencies;
- training requirements and implementation plan and programme;
- a plan and timetable for implementing the Health and Safety Plan;
- proposed method of implementing the contractor's Health and Safety Plan;
- proposed reporting format and health and safety information to be provided in monthly and quarterly progress reports.

The contractor shall, as may be required by the Owner, translate into local languages parts of the final version of the contractor's Health and Safety Plan.

The contractor shall report on the implementation, monitoring and performance of the plan in each Progress Report.

Safety Officer

The contractor shall appoint a Site Safety Officer to undertake the general responsibilities specified in relevant clauses of the Conditions of Contract. The specific responsibilities, roles, authorities and functions of the Site Safety Officer shall be set out in the Health and Safety Plan.

Safety Committee

Within a prescribed time (e.g. 60 days from beginning of works), a Safety Committee shall be established with representatives of the Owner and the contractor. The Safety Committee shall review general safety policy at the construction areas and its specific responsibilities, roles, authorities and functions shall be set out in the Health and Safety Plan. The responsibilities of the Safety Committee shall include:

- setting the procedures for safety meetings;
- defining the requirements for safety monitoring and reporting;
- defining the role and responsibilities of all relevant health and safety personnel;
- reviewing emergency procedures for responding to a health or safety emergency;
- reviewing the implementation of the Plan, including safety education, safety clothing, extent of worker awareness and prominence of safety signs and reporting.

The Safety Committee shall meet at prescribed intervals (e.g. quarterly) or after particular circumstances at the request of the Owner or the contractor.

Safety of Personnel

The contractor shall ensure that safe work practices are developed and adopted by all personnel. Such safe working practices shall be developed in respect of safety equipment, barriers and signals for dangerous areas, noise protection, lighting, equipment management, order and tidiness, signs, fire prevention and fighting, smoking, fire extinguishers, house-keeping, heating and/or cooling devices, paint and painting, emergency procedures, instructions, electrical activities, working at heights, safe transport and lifting, forklift trucks, hoisting, welding/burning, storage and handling of gas, work inside confined spaces, work in tunnels and underground works, dangerous/flammable products, hand tools, radiographic inspections, storage and handling of radio-elements, issue of work permits, explosives, rock drillings, rock bolting, shotcreting, concrete placement, crane operations, earth moving and excavation plant and equipment, and vehicle driving.

Emergency Procedures

Emergency procedures shall be prepared as part of the Health and Safety Plan and issued separately. The contractor shall update all emergency procedures each time there is a material change to working conditions. These emergency procedures, among other things, shall anticipate health and safety aspects of reservoir impoundment and variable downstream flow releases during cofferdam operations, first filling and project operations.

9.4.3 Institutional strengthening in Ethiopia

Institutional strengthening will be required in relation to environmental management and monitoring capacities for resettlement, impacts of road and dam construction and associated works, and impacts of construction of transmission line works (subject to the capacity of EEPCO's already existing EMU at the time of the project).

It has been noted in Chapter 4 that the Consultant's consultations in the project's primary host region, Benishangul Gumuz, revealed that the local administration and other stakeholders appealed for assistance with institutional strengthening for the project.

Table 9.1 : Consolidated EMP for Mitigation and Enhancement Works in Ethiopia

Project activities / Environmental issues/impacts in Ethiopia	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	**Supervision**
Pre-construction Phase			
Project feasibility study Full environmental study	Review and submission of EIA documentation to ENTRO, regional and federal EPA for evaluation Detailed drawing showing land acquisition requirements Preparation and subsequent evaluation and approval of RAP Land and property expropriation survey Assessment and payment of compensation and implementation of RAP	Project Owner/consultant National and regional government departments, as appropriate	
Training	Training and capacity building of relevant organizations Training for environmental management and safety	Project Owner/consultant	
Project study and contract documents	Ensure that all government and funding agency requirements and procedures relating to EIA are pursued Ensuring that environmental protection measures are stipulated in contract documents, including occupational health and safety plan. Implementation of land and property acquisition procedures including payment of compensation	Project Owner/consultant National and regional government departments, as appropriate	

- [1] Columns to indicate location, timing and costs should be added to this table for the project EMP at feasibility stage

Project activities / Environmental issues/impacts in Ethiopia	**Proposed mitigation/enhancement Measures[1]**	**Responsible agents**	
		Implementation	**Supervision**
Construction Phase			
1. principal engineering construction impacts from construction of access road, dam excavation, quarries, civil works, etc			
Erosion and sediment control – all construction sites	• Preserve top soil stripped from road edges and construction sites for re-use • Discourage grazing in disturbed areas until regeneration has taken place and new growth is firmly established • Erodible surfaces should be cut only during dry weather where practicable and re-planted as soon as possible	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Spoil disposal	• Minimise numbers of spoil heaps; stabilize and re-vegetate them; consider dumping in the reservoir inundation area where practicable	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Quarry rehabilitation	• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely	Contractor	Project Owner and EMU
Water quality	• Provide adequate sediment settling facilities for particulate matter in drainage from all works sites.	Contractor	Project Owner and EMU
Chemical waste/spillage	• Ensure toxic compounds are not located near rivers and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Emergency plan for hazardous materials	• Provide safe systems for hazardous waste disposal	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission

Project activities / Environmental issues/impacts in Ethiopia	**Proposed mitigation/enhancement Measures**[1]	**Responsible agents**	
		Implementation	**Supervision**
			lines
Dust and emissions control	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Noise control	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Vegetation clearing	• Remove woody material from reservoir area according to recommendations	Contractors	Project Owner and EMU
Landscaping and re-vegetation	• Minimize vegetation clearing for project infrastructure works and rehabilitate sites • Remove potential "eyesores" of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing points	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Coffer dam and reservoir impoundment	• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures	Contractor	Project Owner and EMU

Project activities / Environmental issues/impacts in Ethiopia	**Proposed mitigation/enhancement Measures**[1]	**Responsible agents**	
		Implementation	**Supervision**
	• Liase with RAP officers		
Environmental training for construction workers	• Provide training on environmental protection measures for flora and fauna	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
Construction work camps	• Provide appropriate facilities for accommodation and recreation of workforce at dam site camps • Provide appropriate facilities for accommodation at transmission line fly camps	Contractor Contractor	Project Owner and EMU EEPCO's EMU
Project staff health	• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health and safety education for workforce, including education on STDs and HIV/AIDS	Contractor	Project Owner and EMU and EEPCO's EMU concerning transmission lines
2. Reservoir sedimentation	• Project to contribute to implementation of Abbay Watershed Management Program	To be determined	To be determined
3. Reservoir slope stability and reservoir induced seismicity	• Implement precautionary measures as may be recommended	Contractor	Project Owner and EMU
4. Groundwater	• Utilise raised groundwater if and where significant for beneficial use • Provide drainage for raised groundwater levels if and where impacts are adverse	Regional government health and water departments	Project Owner and EMU, regional EPA

Project activities / Environmental issues/impacts in Ethiopia	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	**Supervision**
5. Disease vectors	• Provide health care education, clinics and mosquito nets	Contractor for workforce Government Health Department for others	Project Owner and EMU
6. Aquatic environment and fishing	• Avoid where possible, otherwise minimise adverse impacts on watercourses by implementation of above mitigation measures for project construction • Implement a reservoir fisheries development program	Contractor Fisheries Department	Project Owner and EMU Project Owner, EMU & regional EPA
7. Natural terrestrial habitats and wildlife	• Avoid where possible, otherwise minimise adverse impacts on habitats by implementation of above mitigation measures for project construction • Avoid damage to any notified habitat sites of special scientific, historical or cultural interest • Implement conservation management measures in reservoir perimeter buffer zone and at agreed environmental offset sites, e.g. Dabus Valley Controlled Hunting Area	Contractor Contractor Wildlife Department	Project Owner, EMU & regional EPA Project Owner, EMU & regional EPA Project Owner, EMU & regional EPA
8. Socio economic impacts due to the various construction activities including the filling of the reservoir			
Loss of arable land due to project construction, including along transmission line routes	Early notification and consultation with the affected farmers; consider alternative routes locally as a result of consultations. Provide just compensation expeditiously	Project Owner, EMU, RMU & regional government department. EEPCO's EMU concerning transmission lines	Regional EPA
Houses and fixed assets lost due to construction, including along transmission line routes	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, EMU, RMU & regional government department. EEPCO's EMU concerning transmission lines	Regional EPA

Project activities / Environmental issues/impacts in Ethiopia	**Proposed mitigation/enhancement Measures**[1]	**Responsible agents**	
		Implementation	**Supervision**
Grazing and natural resources lost due to construction, including along transmission line routes	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, EMU, RMU & regional government department. EEPCO's EMU concerning transmission lines	Regional EPA
Infrastructure lost due to construction, including along transmission line routes	Early notification and consultation with the affected communities and regional government. Provide mitigation measures	Contractor	Project Owner, EMU, RMU & regional EPA. EEPCO's EMU concerning transmission lines
Local communications, including ferries.	Provide alternative river crossing facilities and compensate for ferrymen's incomes	Contractor	Project Owner, EMU, RMU & regional EPA
Resettlement, including any along transmission line routes	Implement a comprehensive resettlement action plan (RAP), including a development program for host areas, host communities and PAPs; support viable income generating schemes	Project Owner, RMU, EMU and regional government department. EEPCO's EMU concerning transmission lines	Regional EPA
Physical/cultural resources	Implement recommendations, if any, for detailed survey, documentation and salvage	Project Owner, EMU, national and regional museums. EEPCO's EMU concerning transmission lines	National Museum
Public health	Implement health education/awareness and improve health services to vulnerable communities (for those not specifically included in RAP and associated development plan)	Project Owner, EMU, RMU, regional government health department	Regional EPA
Graveyards	Implement recommendations of religious leaders, as may be required	To be determined	Regional EPA
Employment	Implement plans for preferential employment of local people, with training	Contractors	Project Owner, EMU. EEPCO's EMU concerning transmission lines
Local commerce and trade	Avoid causing price inflation of local produce	Contractor	Project Owner, EMU

Project activities / Environmental issues/impacts in Ethiopia	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Energy use	Make salvaged timber from construction sites, including reservoir basin clearance, available to local communities Accelerate plans for rural electrification	Contractor EEPCO	Project Owner, EMU
Downstream river crossings and safety	Implement recommended warning systems	Contractor, then Project Owner	EMU and regional EPA
Downstream recession agriculture	Provide just compensation expeditiously and/or provide pumps and fuel costs	Project Owner, EMU	Regional EPA
Downstream gold panning	Provide just compensation expeditiously	Project Owner, EMU	Regional EPA
Public relations	Implement first class communication system and procedures for keeping the public informed about project's progress	Project Owner	National and Regional EPA
Project induced developments	Anticipate, plan and develop infrastructure and other responses for probable induced developments	Project Owner, EMU, RMU, regional government departments	Regional EPA
Operational Phase			
Dam and river safety	Ensure all dam safety measures and warning systems are functional/updated	Project Owner, EMU	Regional EPA
Resettlement	Ensure proper implementation of resettlement and development program	Project Owner, RMU, EMU	Regional EPA
Reservoir sedimentation	Locally, ensure project area's rehabilitated areas, including road verges, are maintained in first class condition. Re-plant as required. Must be model for others to see. Pro-actively encourage and maintain financial contributions to watershed management of Abbay basin. Insist on receiving reports on areas conserved and verify these.	Project Owner, EMU	Regional EPA
Reservoir fisheries development and water based recreation	Ensure facilities, stocking, training, and commerce are maintained/improved. Support multiple uses of reservoir consistent with good environmental practice.	Fisheries Department	Project Owner, EMU
Environmental offset(s) and reservoir	Continue support for management of buffer zones and offsets. Facilitate waterbird and other surveys by NGOs.	Wildlife Department, Project Owner	Ethiopian Wildlife and Natural History Society

Project activities / Environmental issues/impacts in Ethiopia	**Proposed mitigation/enhancement Measures[1]**	**Responsible agents**	
		Implementation	**Supervision**
Transmission Lines Right of Way - encroachment	Maintain vigilance on adopted restrictions of land use along transmission lines, including houses with respect to electro-magnetic fields	EEPCO and EEPCO's EMU	Regional EPA
Completed project mitigation and enhancement measures - general	Meet any residual liabilities helpfully and maintain interest in good practices	Project Owner, EMU, RMU, regional government departments	Regional EPA
Project induced developments	Continue to anticipate, plan and develop infrastructure and other responses for probable induced developments	Project Owner, EMU, RMU, regional government departments	Regional EPA
Public relations	Continue to maintain first class communication system about the project. Employ local people wherever possible. Develop educational and environmental tours for visitors/groups.	Project Owner	

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Management Plan. The above table is a proto-type of the EMP; it cannot now be completed with respect to location, timing and costs for each and every issue. Many of these are unknown at pre-feasibility stage. Some cost estimates of environmental and social mitigation measures are included in Chapter 11.

9.4.4 Responsibilities for Environmental Management in Sudan

A draft EMP for works in Sudan is presented in Table 9.2. It covers the transmission lines and associated works areas within Sudan, and mitigation and enhancement measures required in Sudan for the downstream impacts of the project.

The overall responsibility for the day-to-day coordination and administration of the implementation of the environmental and social management and monitoring plans set out in the EIA for activities in Sudan, when developed at feasibility level, will lie with the project Owner and Ministry of Irrigation and Water Resources (MIWR) in Khartoum. NEC will have responsibility for the works on the project's new and upgraded transmission lines.

The project proponent will be responsible, following feasibility studies, for submitting the EIA report, with its EMP and RAP plans (as may be required for transmission lines in Sudan) to the Higher Council for Environment and Natural Resources (HCENR) in Khartoum and other competent authorities for evaluation according to internal procedures in Sudan.

It is envisaged that NEC, on behalf of the project Owner, will compile "the Owner's requirements" in consultation with stakeholders and lenders of finance for the transmission line component of the project. It is envisaged that MIWR, on behalf of the project Owner, will compile "the Owner's requirements" in consultation with stakeholders and lenders of finance for the river training and irrigation components of the project. In all cases, it is envisaged that the Owner's requirements will cover, *inter alia*, environmental protection measures presented in the project's EMP. As with the project components in Ethiopia, the Owner's requirements are made known in tender documents and contractors are required in their bids to demonstrate their social and environmental awareness and capability in meeting the Owner's requirements. Once contracts are awarded, environmental management (protection) and monitoring plans will be prepared by contractors, in accordance with the project's EMP, for approval of the Owner. These plans will be site specific, updated and reported on regularly by contractors.

The Owner (in liaison with, or through the delegated agents, NEC and MIWR) will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up trust and confidence about the project. Regarding environment, the Owner will use his public relations procedures and communications to make known details of the project and its time schedule, impacts and mitigation measures, and grievance procedures. Among the many issues to be made widely known in Sudan are those relating to compensation and mitigation measures, the schedule of movements required in the transmission line RAP plan, dam safety and the downstream flow release regime during the early years of construction, during first-filling of the reservoir and during the project operational phase. To these must be added all relevant aspects of river training works and works for conversion of flood recession agriculture to irrigation.

9.4.5 Institutional strengthening in Sudan

Institutional strengthening will be required in relation to environmental management and monitoring capacities for construction of transmission line works, river training and conversion of flood recession agriculture to pumped irrigation schemes. It is envisaged that this institutional strengthening will be required for NEC and MIWR – the principal agencies involved with contractors. For example, for environmental protection and resettlement aspects of transmission lines, it is envisaged that NEC will be supported by an environmental management unit (EMU) and a resettlement management unit (RMU) for the duration of works, and for some time in the operational phase. (In practice, these units may be combined as one unit because the resettlement is expected to be small in scale, but this is not yet confirmed). For river channel morphology issues, it is anticipated that a department or section may require to be established in MIWR, with a budget for this purpose, as has occurred in Egypt because of river morphology adjustments below High Aswan Dam.

With regard to the mitigation measure to convert flood recession agriculture to pumped irrigation along reaches of the Blue Nile and Main Nile, this may be implemented and supervised by MIWR also. Depending on many factors, an agency within or outside the Ministry may be required with all the institutional strengthening this would imply. This might be on similar lines to the "Authority of Changing Basin Irrigation" established in Egypt to convert almost 2 million feddan dependent on the annual flood before High Aswan Dam. The change to perennial irrigation involved river, canal and pumping facilities to ensure two crops, and sometimes three crops, were produced. It involved forming Co-operative Societies and providing farmers with services – tractors, fertilizers, etc on loans to be paid back after harvest. It is currently envisaged that conversion of flood recession agriculture to pumped irrigation would have to be completed **before** the beginning of first filling of the upstream Ethiopian storage.

In addition, the Higher Council for Environment and Natural Resources and, at local level, all relevant State Councils for Environment and Natural Resources, will be involved, as provided for under the Environmental Protection Act of 2001. The principal non-government organisation appears likely to be the Sudanese Environmental Conservation Society (with regard to all mitigation measures). As the State Councils for Environment and Natural Resources have not yet been established for the various states along the Blue and Main Nile, and may not be established by the time the project is implemented, a very significant amount of planning, training and support is envisaged to establish them. This is clear from the many works to be managed and monitored in pre-construction, construction and operational phases listed in Table 9.2.

Table 9.2 : Consolidated EMP for Mitigation and Enhancement Works in Sudan

Project activities / Environmental issues/impacts in Sudan	**Proposed mitigation/enhancement Measures**[2]	**Responsible agents**	
		Implementation	**Supervision**
Pre-construction Phase			
Project feasibility study for mitigation and enhancement of impacts resulting from regulatory storage development in Ethiopia Full environmental study	Review and submission of EIA documentation to ENTRO and HCENR for evaluation Detailed drawings showing land acquisition requirements (**transmission lines, river crossings and safety, river training, conversion of flood recession agriculture to irrigation**) Preparation and subsequent evaluation and approval of RAP (for transmission lines) Land and property expropriation survey Assessment and payment of compensation and implementation of RAP	Project Owner/consultant National and state government departments, as appropriate	
Training	Training and capacity building of relevant organizations	Project Owner/consultant	
Project study and contract documents	Ensure that all government and funding agency requirements and procedures relating to EIA are pursued Ensuring that environmental protection measures are stipulated in contract documents, including occupational health and safety plan. Implementation of land and property acquisition procedures including payment of compensation	Project Owner/consultant National and regional government departments, as appropriate	HCENR and SCENRs

- [2] Columns to indicate location, timing and costs should be added to this table for the project EMP at feasibility stage

Project activities / Environmental issues/impacts in Sudan	**Proposed mitigation/enhancement Measures[2]**	**Responsible agents**	
		Implementation	**Supervision**
Construction Phase			
1. Principal engineering construction impacts of transmission lines and related works			
Erosion and sediment control – all construction sites	• Preserve top soil stripped from acces roads and tower and other construction sites for re-use	Contractor	Project Owner and NEC's EMU
Spoil disposal	• Minimise numbers of spoil heaps; stabilize and re-vegetate them	Contractor	Project Owner and NEC's EMU
Water quality	• Provide adequate sediment settling facilities for particulate matter in drainage from all works sites.	Contractor	Project Owner and NEC's EMU
Chemical waste/spillage	• Ensure toxic compounds are not located near rivers and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	Contractor	Project Owner and NEC's EMU
Emergency plan for hazardous materials	• Provide safe systems for hazardous waste disposal	Contractor	Project Owner and NEC's EMU
Dust and emissions control	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	Contractor	Project Owner and NEC's EMU
Noise control	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	Contractor	Project Owner and NEC's EMU

Project activities / Environmental issues/impacts in Sudan	Proposed mitigation/enhancement Measures[2]	Responsible agents	
		Implementation	Supervision
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	Contractor	Project Owner and NEC's EMU, Antiquities and Museums National Corporation
Landscaping and re-vegetation	• Minimize vegetation clearing for project infrastructure works and rehabilitate sites	Contractor	Project Owner and NEC's EMU
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste to approved facilities	Contractor	Project Owner and NEC's EMU
Environmental training for construction workers	• Provide training on environmental protection measures for flora and fauna	Contractor	Project Owner and NEC's EMU
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for construction materials	Contractor	Project Owner and NEC's EMU
Construction work fly camps	• Provide appropriate facilities for accommodation of workforce	Contractor	Project Owner and NEC's EMU
Project staff health	• Provide safe drinking water to workers • Establish on-site first aid facilities • Provide health and safety education for workforce	Contractor	Project Owner and NEC's EMU
Aquatic environment	• Avoid where possible, otherwise minimise adverse impacts on watercourses by implementation of above mitigation measures for project construction	Contractor	Project Owner and NEC's EMU
Natural terrestrial habitats and wildlife	• Avoid where possible, otherwise minimise adverse impacts on habitats by implementation of above mitigation measures for project construction • Avoid damage to any notified habitat sites of special scientific interest	Contractor	Project Owner and NEC's EMU

Project activities / Environmental issues/impacts in Sudan	Proposed mitigation/enhancement Measures[2]	Responsible agents	
		Implementation	Supervision
2. Socio economic impacts due to the various transmission line construction activities			
Loss of arable and grazing land due to project construction	Early notification and consultation with the affected farmers; consider alternative routes locally as a result of consultations. Provide just compensation expeditiously	Project Owner, NEC's EMU/RMU	SCENR
Houses and fixed assets lost due to construction	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, NEC's EMU/RMU	SCENR
Infrastructure lost due to construction	Early notification and consultation with the affected communities and state governments. Provide mitigation measures	Contractor	Project Owner and NEC's EMU, SCENR
Resettlement	Implement a resettlement action plan (RAP),	Project Owner, NEC's EMU/RMU	SCENR
Physical/cultural resources	Implement recommendations, if any, for detailed survey, documentation and salvage	Project Owner and NEC's EMU, Antiquities and Museums National Corporation	Antiquities and Museums National Corporation
Graveyards	Implement recommendations of religious leaders, as may be required	To be determined	HCENR and SCENR
Employment	Implement plans for preferential employment of local people, with training	Contractors	NEC's EMU
Energy use	Make salvaged timber from construction sites available to local communities Accelerate plans for rural elecrification	Contractor NEC	NEC's EMU
3. Construction impacts of upstream Ethiopian regulatory storage works			
River crossings and safety	Implement recommended warning systems Provide alternative river crossing facilities for pedestrians and livestock Provide compensation, as may be required	Contractor, then MIWR Contractor Project Owner through Sudan government department	HCENR and SCENR MIWR and SCENR MIWR and SCENR
Gold panning – Ethiopian border to Roseires	Provide just compensation expeditiously (if gold panning confirmed in reach)	Project Owner through Sudan government department	MIWR and SCENR

Project activities / Environmental issues/impacts in Sudan	Proposed mitigation/enhancement Measures[2]	Responsible agents	
		Implementation	**Supervision**
Increased trash loads at Roseires	Best practices for upstream reservoir basin clearance to minimise trash Extra vigilance at Roseires	Contractor in Ethiopia NEC	Project Owner, EMU SCENR
4. Construction impacts of Sudan's mitigation/enhancement works for impacts of upstream Ethiopian regulatory storage works			
Conversion of recession agriculture to irrigation	Implement mitigation measures for these mitigation works. (Terms of reference of comprehensive study to be agreed. This will itself generate many mitigation measures, including attention to responsibilities for financing provision of artificial fertilizers and pumping costs). Provide just compensation expeditiously	Contractor Project Owner through Sudan government department	MIWR and SCENR MIWR and SCENR
River training	Implement mitigation measures for these mitigation works. (Terms of reference of comprehensive study to be agreed). Provide just compensation expeditiously	Contractor Project Owner through Sudan government department	MIWR and SCENR MIWR and SCENR
Operational Phase			
Regulated flows; greater flows in dry season	Uplift in energy generation at Roseires, Sennar and Merowe	NEC	
Regulated flows; greater flows in dry season	Additional irrigation	MIWR	
Regulated flows; higher levels in dry season	Reduced pumping costs	MIWR	
Regulated flows; higher levels in dry season	Improved navigation conditions	Boat operators	
Reduced sediment transport	Reduced dredging costs at Roseires	NEC	
Reduced sediment transport	Reduced irrigation canal and drainage canal desilting maintenance costs	MIWR	
Reduced sediment transport	Reduced water supply treatment costs	MIWRI, NEC; urban, industrial and rural water supplies	
Reduced sediment transport	Reduced pump replacement costs	MIWR; urban, industrial and rural water supplies	
Regulated flows and reduced sediment transport	Increased reservoir fisheries production	Fisheries Department	

Project activities / Environmental issues/impacts in Sudan	Proposed mitigation/enhancement Measures[2]	Responsible agents	
		Implementation	Supervision
Reduction in flooding	Reduced health problems, urban property flooding, and reduced infrastructure maintenance costs	MIWR	
Dam and river safety	Ensure all dam safety measures and warning systems are functional/updated	Project Owner, NEC, MIWR	HCENR and SCENR
Transmission Lines Right of Way - encroachment	Maintain vigilance on adopted restrictions of land use along transmission lines, including houses with respect to electro-magnetic fields	NEC	HCENR and SCENR
River training works	Ensure maintenance of mitigation measures, and vigilance/mitigation for new sites of river bank erosion	Project Owner, NEC, MIWR	HCENR and SCENR
New irrigation areas and areas (formerly flood recession agriculture) converted to irrigation	Ensure maintenance continues	Project Owner, NEC, MIWR	HCENR and SCENR

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Management Plan. The above table is a proto-type of the EMP; it cannot now be completed with respect to location, timing and costs for each and every issue. Many of these are unknown at pre-feasibility stage. Some indicative cost estimates of environmental mitigation measures are included in Chapter 11.

9.4.6 Financing mitigation measures, environmental management and monitoring in Sudan

The issues of financing mitigation measures in Sudan, and environmental management and monitoring in Sudan, for impacts caused by a development in Ethiopia, are complex. They are beyond the scope of this report. However, these institutional and financial issues are believed capable of solution because, on balance, it appears that future studies will confirm our findings that the potential positive benefits of the Mandaya project in Sudan will be found to be far in excess of negative impacts and the cost of mitigating these.

9.4.7 Management at Mandaya and Roseires

There will be need for very close cooperation between managers at Mandaya and Roseires (and by extension, at Sennar and Merowe), as everywhere in the cases of developing and operating hydropower dams in cascade.

It is envisaged that management, dam safety issues, special surveys and monitoring of river flows (at a new Mandaya station and an upgraded Border river gauging station), reservoir water quality, sedimentation and aquatic ecology (including weed growth, fish and fisheries) will benefit from cooperation and free exchange of information and data. Synchronization of some surveys and monitoring will be particularly valuable.

The details of this cooperation require to be considered in following studies. Decisions on road communications between Mandaya and Damazin/Roseires may have a significant bearing on the success of this cooperation in management.

9.4.8 Responsibilities for Environmental Management in Egypt

The overall responsibility for the day-to-day coordination and administration of the implementation of the environmental and social management and monitoring plans set out in the EIA for activities in Egypt, when developed at feasibility level, will lie with the project Owner and Ministry of Water Resources and Irrigation (MWRI). The Egyptian Electric Holding Company (EEHC), through its various agencies as required, will have responsibility for the project’s new and upgraded transmission lines.

The project proponent will be responsible, following feasibility studies, for submitting the EIA report, with its EMP and RAP plans (as may be required for transmission lines in Egypt if settled areas cannot be avoided) to the Egyptian Environmental Affairs Agency (EEAA) and other competent authorities for evaluation according to internal procedures in Egypt.

It is envisaged that EEHC, on behalf of the project Owner, will compile “the Owner’s requirements” in consultation with stakeholders and lenders of finance for the transmission line component of the project. It is envisaged that MWRI and the Ministry of Agriculture and Land Reclamation (MALR), on behalf of the project Owner, will compile “the Owner’s requirements” in consultation with stakeholders and lenders of finance for any construction works in relation to fisheries, navigation and irrigated agriculture mitigation components of the project. In all cases, it is envisaged that the Owner's requirements will cover, *inter alia*, environmental protection measures presented in the project's EMP. As with the project components in Ethiopia and Sudan, the Owner's requirements are made known in tender documents. Once contracts are awarded, environmental management (protection) and monitoring plans will be prepared by contractors, in accordance with the project's EMP, for approval of the Owner. These plans will be site specific, updated and reported on regularly by contractors.

The Owner (in liaison with, or through the delegated agents, EEHC, MWRI and MALR) will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up trust and confidence about the project. Among the issues to be made widely known in Egypt are those relating to compensation and mitigation measures, the schedule of movements required (if any) in the transmission line RAP plan, dam safety and the estimated range of changes in Lake Nasser/Nubia levels during first-filling of the reservoir in Ethiopia and during the project operational phase. To these must be added all relevant aspects of changes in fisheries, navigation and irrigated agriculture and proposals to mitigate them in Aswan and New Valley Governorates.

9.4.9 Institutional strengthening in Egypt

Institutional strengthening may be required in relation to environmental management and monitoring capacities for construction of transmission line works (EEHC), and for implementation of any mitigation work associated with fisheries, navigation and irrigated agriculture at and around Lake Nasser/Nubia (MWRI and MALR). For example, for environmental protection and resettlement aspects of transmission lines, it is envisaged that EEHC will be supported by an environmental management unit (EMU) and a resettlement management unit (RMU) for the duration of works, and for some time in the operational phase. (In practice, as for NEC in Sudan, these units may be combined as one unit because the resettlement is expected to be small in scale, but this is not yet confirmed).

In addition, the EEAA will be involved and may require to provide strengthen its operations in the Lake Nasser area. The principal non-government organisations appear likely to include one or more of the following: Centre for Development Services (CDS)/Desert Development Centre (DDC) – American University in Cairo, the Egyptian Swiss Development Fund (ESDF), World Food Programme (WFP), and the Wadi Allaqi Projec (Universities of the South Valley in Aswan and Glasgow, U.K). Their roles are summarised in Chapter 2 and their experience and presence in the Lake Nasser area is relevant to contributing to the design, management and monitoring of mitigation measures. Thus support from the project is expected to be necessary. This is clear from the various works to be managed and monitored in pre-construction, construction and operational phases listed in Table 9.3.

9.4.10 Financing mitigation measures, environmental management and monitoring in Egypt

The issues of financing mitigation measures in Egypt, and environmental management and monitoring in Egypt, for impacts caused by a development in Ethiopia, are complex. They are beyond the scope of this report. However, these institutional and financial issues are believed capable of solution because, on balance, it appears that future studies will confirm our findings that the potential positive benefits in Egypt of internationally-based regulatory storage works in Ethiopia will be found to be far in excess of negative impacts and the cost of mitigating these.

There are two principal reasons for this.

Firstly, sedimentation of Lakes Nasser/Nubia is progressively reducing the usable yield for Egypt's population; the reduction in the lake's rate of sedimentation has to be beneficial for Egypt in the medium and long term.

Secondly, although some costs would be involved in terms of reduced power generation at Aswan by operating Lake Nasser/Nubia at a lower level, made possible by regulatory storage and releases in Ethiopia, the possibility of reducing some of the useless evaporation losses and converting these into useful water supplies in Egypt is expected to be very beneficial in the medium and long term, as demands for additional water supplies increase.

Table 9.3 : Consolidated EMP for Mitigation and Enhancement Works in Egypt

Project activities / Environmental issues/impacts in Egypt	**Proposed mitigation/enhancement Measures**[3]	**Responsible agents**	
		Implementation	**Supervision**
	Pre-construction Phase		
Project feasibility study for interconnecting transmission line, and mitigation and enhancement of impacts, resulting from regulatory storage development in Ethiopia Full environmental study	Review and submission of EIA documentation to ENTRO and EEAA for evaluation Detailed drawings showing land acquisition requirements (**transmission line, Lake Nasser/Nubia fisheries and related lake based agriculture/irrigation and navigation**) Preparation and subsequent evaluation and approval of RAP (for transmission lines) Land and property expropriation survey Assessment and payment of compensation and implementation of RAP	Project Owner/consultant National, governorate departments as appropriate	
Training	Training and capacity building of relevant organizations	Project Owner/consultants	
Project study and contract documents	Ensure that all government and funding agency requirements and procedures relating to EIA are pursued Ensuring that environmental protection measures are stipulated in contract documents, including occupational health and safety plan. Implementation of land and property acquisition procedures including payment of compensation	Project Owner/consultant National, governorate departments as appropriate	

- [3] Columns to indicate location, timing and costs should be added to this table for the project EMP at feasibility stage

Project activities / Environmental issues/impacts in Egypt	Proposed mitigation/enhancement Measures[3]	Responsible agents	
		Implementation	Supervision
Construction Phase			
1. Principal engineering construction impacts of transmission lines and related works			
Erosion and sediment control – all construction sites; Spoil disposal; Water quality	• Implement environmental protection measures as appropriate for desert environment	Contractor	Project Owner and EEHC's EMU
Chemical waste/spillage	• Ensure toxic compounds are not located near rivers and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	Contractor	Project Owner and EEHC's EMU
Emergency plan for hazardous materials	• Provide safe systems for hazardous waste disposal	Contractor	Project Owner and EEHC's EMU
Dust and emissions control	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	Contractor	Project Owner and EEHC's EMU
Noise control	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	Contractor	Project Owner and EEHC's EMU
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	Contractor	Project Owner and EEHC's EMU, Supreme Council of Antiquities

Project activities / Environmental issues/impacts in Egypt	Proposed mitigation/enhancement Measures[3]	Responsible agents	
		Implementation	Supervision
Landscaping	• Minimize vegetation clearing, where vegetation exists, for project infrastructure works • Rehabilitate works areas to minimise potential for dust and to ensure public safety	Contractor	Project Owner and EEHC's EMU
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste to approved facilities	Contractor	Project Owner and EEHC's EMU
Environmental training for construction workers	• Provide training on environmental protection measures	Contractor	Project Owner and EEHC's EMU
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for construction materials	Contractor	Project Owner and EEHC's EMU
Construction work fly camps	• Provide appropriate facilities for accommodation of workforce	Contractor	Project Owner and EEHC's EMU
Project staff health	• Provide safe drinking water to workers • Establish on-site first aid facilities • Provide health and safety education for workforce	Contractor	Project Owner and EEHC's EMU
Aquatic environment	• Avoid where possible, otherwise minimise adverse impacts on watercourses by implementation of above mitigation measures for project construction	Contractor	Project Owner and EEHC's EMU
Natural terrestrial habitats and wildlife	• Avoid where possible, otherwise minimise adverse impacts on habitats by implementation of above mitigation measures for project construction • Avoid damage to any notified habitat sites of special scientific interest	Contractor	Project Owner and EEHC's EMU

Project activities / Environmental issues/impacts in Egypt	Proposed mitigation/enhancement Measures[3]	Responsible agents	
		Implementation	Supervision
Socio economic impacts due to the various transmission line construction activities			
Loss of irrigated land due to project construction	Early notification and consultation with the affected farmers; consider alternative routes locally as a result of consultations. Provide just compensation expeditiously	Project Owner, EEHC's EMU/RMU & EEAA	EEAA
Houses and fixed assets lost due to construction	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, EEHC's EMU/RMU & EEAA	EEAA
Infrastructure lost due to construction	Early notification and consultation with the affected communities and governorates. Provide mitigation measures	Contractor	Project Owner and EEHC's EMU
Resettlement	Implement a comprehensive resettlement action plan (RAP), including a development program for host areas, host communities and PAPs; support viable income generating schemes	Project Owner, EEHC's EMU/RMU & EEAA	EEAA
Physical/cultural resources	Implement recommendations, if any, for detailed survey, documentation and salvage	Project Owner and EEHC's EMU, Supreme Council of Antiquities	Supreme Council of Antiquities
Graveyards	Implement recommendations of religious leaders, as may be required	To be determined	EEAA
Employment	Implement plans for preferential employment of local people, with training	Contractors	EEU's EMU

Project activities / Environmental issues/impacts in Egypt	Proposed mitigation/enhancement Measures[3]	Responsible agents	
		Implementation	**Supervision**
2. Construction period impacts of first filling of upstream Ethiopian regulatory storage			
Lake Nasser/Nubia fisheries – reduction in lake level and surface area for fishing, possible reduction in spawning and recruitment	Early notification and consultation with the affected fisheries communities, dependent industries and customers of produce Mitigate and/or provide just compensation expeditiously	Project Owner and MALR MALR	To be determined
Lake Nasser/Nubia's "within lake" recession agriculture – reduction in lake level and surface area; changes in cultivation areas	Early notification and consultation with the affected agricultural communities and customers of produce Mitigate and/or provide just compensation expeditiously	Project Owner and MALR MALR	To be determined
Lake Nasser/Nubia's small-scale pumped irrigation schemes – reduction in lake level and increased head and distance to supply irrigation water	Early notification and consultation with the affected agricultural communities and customers of produce Mitigate and/or provide just compensation expeditiously	Project Owner and MALR MALR	To be determined
Lake Nasser/Nubia's large-scale pumped irrigation schemes – reduction in lake level and increased head for pumping at Mubarak pumping station	Early notification and consultation with MWRI re Mubarak pumping station additional pumping energy costs. Provide compensation for additional energy costs	Project Owner and MALR MALR	To be determined
Lake Nasser/Nubia navigation – reduction in lake level and surface area affecting boat moorings and loading at jetties	Provision of mitigation measures for navigation	Contractor	Project Owner and MALR
Aswan power generation – reduction in Lake Nasser level and reduced head for power generation	Compensation for reduced energy generation	MWRI/EEHC	To be determined
Operation Phase			
Transmission Lines Right of Way - encroachment	Maintain vigilance on adopted restrictions of land use along transmission lines, including houses with respect to electro-magnetic fields	EEHC	EEAA

Project activities / Environmental issues/impacts in Egypt	Proposed mitigation/enhancement Measures[3]	Responsible agents	
		Implementation	Supervision
Lake Nasser/Nubia fisheries – less fluctuations in lake level and surface area for fishing, possible reduction in spawning and recruitment	Review fisheries management plans, including stocking rates. Gain benefits of reduced fluctuations in lake levels and areas	MALR	To be determined
Lake Nasser/Nubia's "within lake" recession agriculture – less fluctuations in lake level and surface area	Review agricultural management plans. Gain benefits of reduced fluctuations in lake levels and areas	MALR	To be determined
Lake Nasser/Nubia's small-scale pumped irrigation schemes – less fluctuations in lake level and surface area	Review agricultural management plans. Gain benefits of reduced fluctuations in lake levels and areas	MALR	To be determined
Lake Nasser/Nubia's large-scale pumped irrigation schemes – less fluctuations in lake level and head for pumping at Mubarak pumping station	Review Mubarak pumping station energy costs for simulated lake levels, with and without upstream regulation	MWRI	To be determined
Lake Nasser/Nubia navigation – less fluctuations in lake level and surface area for boat moorings and loading at jetties	Review navigation management plans. Gain benefits of reduced fluctuations in lake levels and areas	MALR	To be determined
Aswan power generation – less fluctuations in lake level and head for power generation	Review Aswan energy generation for simulated lake levels, with and without upstream regulation	MWRI/EEHC	
Potential for operation of Lake Nasser/Nubia at lower level after first filling of Ethiopian regulatory storage	Potential for reduction in lake Nasser/Nubia evaporation losses and their conversion to usable water supply yield for Egypt, if and when benefits of this are agreed to outweigh reduced power generation at Aswan and any adverse impacts relating to fisheries, irrigated agriculture and navigation	MWRI/EEHC/MALR	

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Management Plan. The above table is a proto-type of the EMP; it cannot now be completed with respect to location, timing and costs for each and every issue. Many of these are unknown at pre-feasibility stage.

9.5 INDEPENDENT PANEL OF EXPERTS FOR THE ENVIRONMENT AND COMMUNITY PROTECTION

The proposed project in Ethiopia is a federal government project but also an international project with environmental impacts in Ethiopia, Sudan and Egypt. As the magnitude and extent of environmental and social impacts are large and wide-ranging, including those downstream, it is envisaged that the project Owner will appoint an independent Panel of Experts for the Environment and Community Protection. (This is in addition to another panel – the Panel of Experts on Dam Safety). The composition of this environmental and social panel is a matter for the future but this report indicates that special expertise in vegetation and vegetation clearance, wildlife habitat and environmental offset planning and management, resettlement and irrigation will be required as a minimum.

Management includes building trust and confidence in the project. In order to build up confidence in the project's implementation of the EMP and RAP, it will be essential that the project Owner makes full use of all means to inform stakeholders about the project and that the Environmental and Community Protection Panel of Experts make its findings known to the public at all times.

This Panel of Experts will therefore not only provide critical guidance to the project Owner (who directs contractors) but also issue candid advice on implementation of the EMP, public relations, liaison, and practical matters concerning all environmental and social aspects of the developing project.

The Panel will review the EMP to ensure that the document is an adequate reflection of the environmental impacts that may result from the development and that the document provides sufficient information on which decisions may be taken.

9.6 MANAGEMENT OF RISKS

No risk assessment has been conducted. Risk assessments are conducted at feasibility stage.

The following comments are made with regard to one issue only – the risk of water not being released to the Blue Nile.

As stated earlier, it is assumed from the outset that shareholders in the company, the Owner of the project, will include the governments of Ethiopia, Sudan and Egypt and one or more private investors. This multinational participation will ensure that a water release regime is defined and agreed before construction and financial closure, and then followed according to the agreement. There should therefore be no political risk of water not being released according to the established program (which may include agreed variants of it).

The risk which some envisage is that relating to terrorist attack. The case is cited of insurgency causing Cahora Bassa hydropower project on Zambezi, with installed capacity of 2,075 MW, being unable to evacuate power for many years because of destruction of a part of its major transmission line. In Cahora Bassa's case, where spillway gates are set in the face of the concrete arch dam, water was released downstream and there was no water shortage for riparian users.

In the case of one or more storage dams in Ethiopia, pre-feasibility designs include low level outlets (and at Mandaya, mid level outlets), that can pass 1,000 m^3/s. These are required during construction and reservoir impoundment in order to make releases for downstream users during the construction phase and first filling. These facilities will continue to be available throughout the project's life. Thus, if for some unforeseen reason, there is unscheduled plant shutdown for any extended period with no turbined flow, the capacity exists to meet downstream demands. It may be noted that this capacity exceeds the normal regulated flow in the dry season.

Thus, risks of Sudan and Egypt not receiving Abbay flows are not foreseen. The risks will be designed out by multinational participation in project ownership and operation, and in engineering design.

9.7 RESETTLEMENT ACTION PLAN

This section outlines the general provisions for a Resettlement Action Plan (RAP) suitable for the proposed hydropower project reservoir and construction works area. (Whilst the hydropower project reservoir and construction works area are the main focus of this section, these provisions also cover the principles of resettlement which will or may apply to more limited amounts of resettlement envisaged for project transmission lines and associated works, and also any other resettlement which may be required as a result of mitigation works along the Blue Nile and Main Nile in Sudan and around Lake Nasser in Egypt).

The RAP should be developed to meet the policy and regulation requirements of the Government of Ethiopia and AfDB/the World Bank for the project in relation to resettlement and compensation. It identifies people affected by the project, the nature and degree of the impacts on them, measures taken to minimize the effects and compensation and other assistance to be delivered to affected people for inevitable negative impacts.

The RAP has been made in line with the assessment of potential losses that were investigated during the pre-feasibility study of the hydropower project and the actions defined to minimize damage or loss to project affected people and the environment. This RAP also considers loss of access to resources (domestic dwellings, crops, vegetation, grazing lands, infrastructures, businesses and services) or displacement and relocation due to construction and operation of the project.

Its objectives are to evaluate all physical or economic impacts, displacement, or temporary or permanent loss of assets or facilities that may be experienced by project-affected communities.

The World Bank's Involuntary Resettlement documentation states the principles of resettlement as:

People should be at least as well off, preferably better off, after resettlement. Fairness and equity are major issues in the resettlement.

The factors to consider in resettlement plans are:

- Institutional and organization capacity needed for resettlement including all responsible bodies and need of training.
- Participation of affected people in decision-making, implementation, operation, and evaluation and monitoring of the resettlement of both settlers and host populations.
- Base line data on affected population; census of population, property and common area inventory, map of receiving area and environmental constraints in the host community.
- Resettlement policy and legal framework. This encompasses definition of affected lands, structure, compensation and entitlement criteria and grievance procedures.
- Development plan for new sites which includes detailed engineering plans and layouts, agricultural development packages, non-agricultural employment packages, monitoring arrangements and environmental protection.
- Transfer arrangements including information campaign, transition monitoring, and maintenance and mobilization schedule.
- Cost estimate, financing plan, implementation schedule and disbursement schedule.

9.7.1 Resettlement Principles

The RAP is prepared in accordance with international best practices on resettlement. These may be summarised as:

- Involuntary resettlement should be avoided, or minimised where unavoidable.
- Where resettlement is unavoidable, resettlement plans and activities should be seen and executed as development programs.
- Resettled persons should be provided with sufficient investment resources (livelihood safeguard projects) in order to restore their livelihoods.
- Displaced persons should be meaningfully consulted, and participate in planning and implementation of resettlement programs.
- Displaced persons should be compensated for their losses at full replacement cost, prior to the move.
- Resettled persons should be assisted with the move and provided with support during the transition period.
- Resettled persons should be assisted with their efforts to improve, or at least restore, their former living standards, income earning capacity and production levels whichever is higher.

9.7.2 Eligibilty

This section of the RAP spells out the categories of people who qualify for resettlement assistance, and the associated eligibility criteria. They are the following:

- People who will be displaced by having to move their place of residence, agricultural production, or business to allow for the construction of the project, or any other associated infrastructure. People who were recorded as project affected people will be regarded as eligible for qualification.
- People who will lose land over which they have established ownership or rights of usufruct (either in a permanent or temporary fashion) to allow for the construction of the project, or any other associated infrastructure. People who were recorded as project affected people in the pre-feasibility study are regarded as eligible for qualification.
- Members of communities who will lose access to their communal resource base. People who were recorded as project affected people (PAPs) during the study will be regarded as eligible for qualification.
- Public and private businesses and property that may have to relocate as a result of the project.
- Worshipers who may be affected through their place of worship having to be relocated.
- Host communities who will receive those displaced are eligible for Livelihood safeguard programs and other benefits that would improve the community in general.

9.7.3 Potential Scale of Resettlement

The population of the project-affected areas in Mandaya and Border comprises several ethnic groups including the Gumuz in Benishangul and the Amharas in Amhara Region. Both projects are intentionally mentioned here because coordinated investment planning indicates both projects, and others in the potential Abbay hydropower cascade, are likely to be needed in due course, and the RAP for one project will need to keep in mind that a RAP for an adjacent project(s) is likely to be needed.

About 600 people are estimated to be directly affected in the Mandaya project area and some 13,900 people in the Border project area. The homes of these PAPs will be totally lost, and their cultivation with some livestock will be affected. Other activities, such as non-timber woodland products, trading, gold panning opportunities and fishing in the river will be affected.

In addition, roads, bridges, fords, schools, stores and clinics will be lost in the Border reservoir area. There is no loss of infrastructure and public and private establishments in the Mandaya project area. The environmental, socio-economic and cultural background of the project areas is given in Chapter 4, and details of potential socio-economic impacts and mitigation measures are given in Chapters 6 and 7 of respective reports.

9.7.4 Organizational Responsibility

The responsibilities for compensation and resettlement rest with ENTRO and the project Owner (to be determined). Regional and sectoral government regulatory and supervisory organs have the responsibility of implementing as well as ensuring mitigation measures are taken properly and timely.

The project Owner should provide both the financial and technical input into the compensation process, as well as significant additional managerial and technical expertise in supporting the resettlement.

The organisations responsible for the resettlement process have the following collective responsibilities in general:

- Oversee the generation of the RAP.
- Ensure maximum participation of the affected people in the planning of their own resettlement and post resettlement circumstances.
- Accept financial responsibility for payment of compensation and other designated resettlement related costs.
- Pay the affected farmers' compensation to the amounts agreed.
- Construct infrastructure in the host resettlement areas, including schools, dispensaries, health centers, water supplies, sanitation facilities, places of worship (mosques and churches) and other infrastructure as per the RAP developed during the feasibility study phase.
- Ensure monitoring and evaluation of the PAPs and the undertaking of appropriate remedial action to deal with grievances and to ensure that income restoration is satisfactorily implemented.

9.7.5 Community participation

Relocating or compensating people requires dialogue with all stakeholders. Extensive consultation with the potentially affected communities has already begun in the pre-feasibility study phase (Chapter 4). This occurred through meetings with affected farmers and others. People have been consulted since the beginning of the project (October 2007) and this process of consultation shall continue in future.

Consultative mechanisms have been structured at two levels. (1) Project Affected Peoples (PAPs) have been consulted individually and in groups, depending on the context; (2) Higher authorities were also consulted and their views solicited.

A note about vulnerable groups is relevant here. Vulnerable groups will have been identified during field data collection and through interviews that will be carried out with the affected population during the preparation of RAP. At the time of implementing the compensation, special attention, support and care will have to be given to vulnerable groups like female-headed households, the elderly and any persons with disabilities. This support can be in rebuilding their houses, and transferring and transporting their household items and materials to the newly constructed residential houses. Even though it may be difficult to quantify the support that will be provided in monetary terms, these supports are considered to be a very important form of “social compensation” for these vulnerable groups

9.7.6 Relocation Areas

The resettlement location of PAPs will be within the same regional states and where possible in the vicinity of the original residence. Most PAPs are from Benishangul. In Benishangul, population density is very low and hence there is no land shortage problem for relocation. (There could be a minor problem in Amhara because of much higher density of the rural population there but the numbers of people affected are very small and not significant compared to Benishangul).

The Benishangul Gumuz Regional State has conducted a study on appropriate establishment of settlement centres with a view to contributing to the improvement of the local people's way of life and improving service provision.

As a result, a total of 38 resettlement villages are identified and ready for resettlement in the areas listed hereunder:

Kamashi	5 Villages
Yaso	6 Villages
Agalo Meti	8 Villages
Belo Jagenfoy	10 Villages
Sirba Abbay	9 Villages

The woreda authorities also report that there are sufficient numbers of sites in the project woredas suitable for resettlement. Hence, in the next stages of project planning, lists of possible additional resettlement villages may be obtained from the authorities.

Regarding resettlement of people from the project-affected areas, the Consultant’s own survey showed that about 28 sub-kebele communities would be affected. A total of 2,781 households or 13,905 people are estimated to reside in the Border reservoir area while Mandaya directly affects 120 households and 600 people.

The socio-economic characteristics of the candidate resettlement locations are very similar to the rest of settlements in the Benishangul Gumuz Region. In general, they are characterized by chronic poverty and lack of necessary infrastructure and services (Chapter 4).

For both projects, and especially for Border in view of the estimated numbers of households, the natural resources and socio-economic baseline surveys of candidate resettlement areas and host villages will clearly need to be on a very substantial and intensive scale to permit competent development plans to be produced.

The investigations and planning may be expected to take at least two or three years. Consideration may be given to establishing a “pilot village” as a model for others, if Benishangul cannot demonstrate an existing model resettlement village which meets the necessary criteria for excellent resettlement. (Establishment of a pilot village can be very important for a major project in some circumstances – it can boost trust and confidence in communities to be resettled and in communities of host areas and alert the local administration and local contractors to what is involved. Also, many lessons in planning and practical application may be learned from a pilot village which then benefit planning and implementation of large-scale resettlement to follow).

Institutional strengthening has already been called for by Benishangul leaders and stakeholders (Chapter 4) and these requirements will require detailed examination in the next phase of study.

9.7.7 Grievance Handling Procedures

Grievance philosophy

In order to ensure that PAP grievances and complaints on any aspect of the land acquisition, compensation, and resettlement are addressed in a timely and satisfactory manner, and that all possible means of filing complaints are available to PAPs to air their grievances, a well defined grievance redress mechanism will be established by the project.

Grievance Redress Mechanisms and Institutional Framework

Grievance redress mechanisms are essential tools for allowing affected people to voice concerns about the resettlement and compensation process as they arise and, if necessary, for corrective action to be taken on time. Such mechanisms are fundamental to achieving transparency in the resettlement process. The suggested dispute or grievance mechanisms are as follows:

Grievance should be clearly stated, orally or written, by a settler or settlers, of any resettlement- and relocation-related problem, concern or complaint.

Grievance handling procedure has three steps described below.

1. **Grievance receiver:** Grievance Receivers shall be established in the woreda office of relocated or host kebeles. The woreda administration shall appoint one or more grievance receiving officers.

   The Grievance Receiver's role is to listen to the concern of the settlers or host communities and gather information and explore alternatives. If the problem is minor the grievance receiver will give the solution. This will be the end of that particular grievance if agreed by the person who filed the grievance. Otherwise the case will be forwarded with advice to the Arbitration Committee.

If required, the Grievance Receiver will investigate all aspects of grievances, including the interviewing of witnesses, and prepare a formal report for the Arbitration Committee, together with recommendations for resolution.

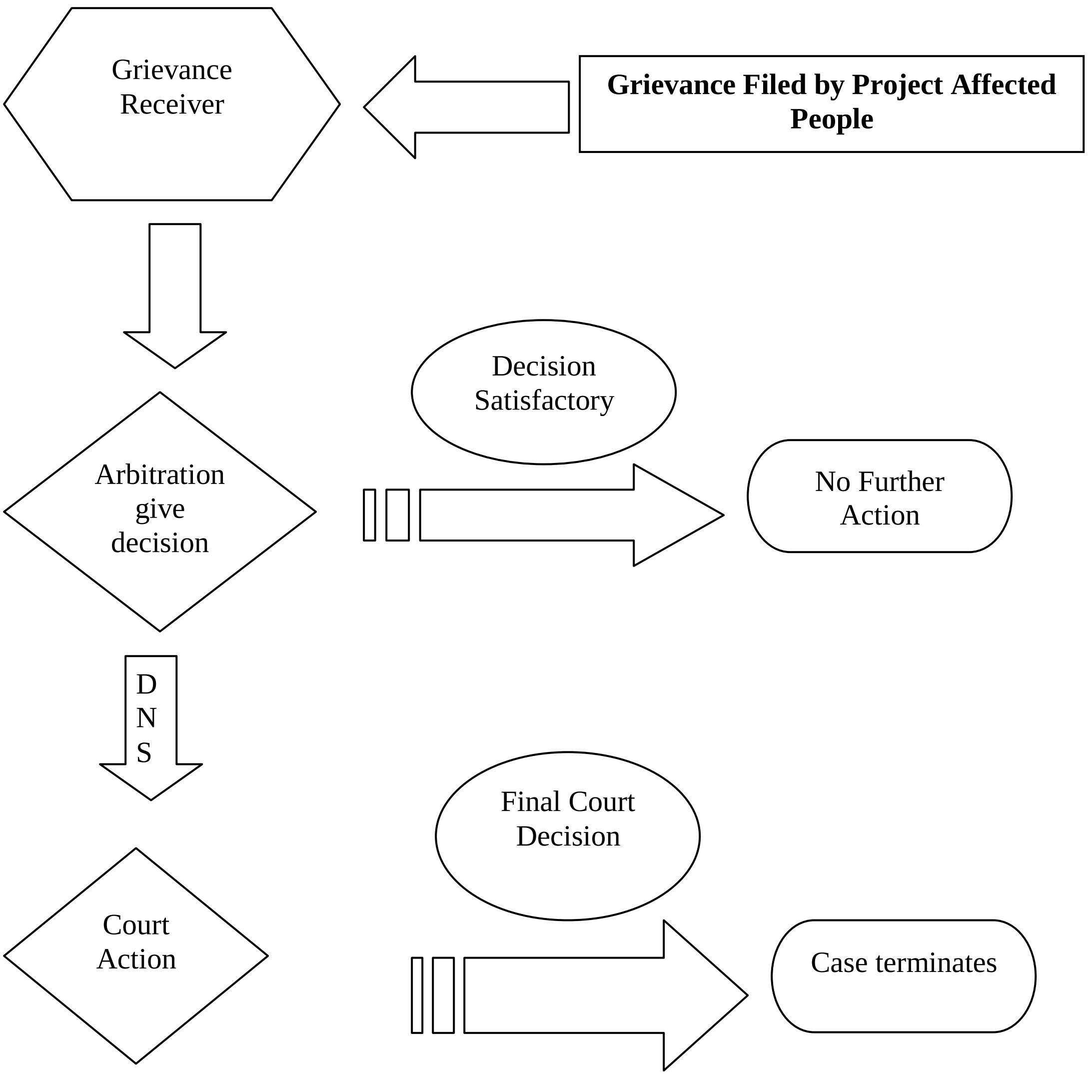
2. **Arbitration Committee:** The Arbitration Committee is next to the Grievance Receiver in the hierarchy to examine the grievance case. The committee members constitute the following.

   - Woreda Administrator
   - Representative of Land Use and Land Administration Authority
   - Local community leaders in affected villages
   - Representatives of PAPs
   - Local NGOs and CBOs

   Disputes are referred to the committee. If deemed necessary by the committee, the case will be re-investigated. The committee shall resolve the problem with fairness. If the person who filed the case is not satisfied the committee will forward the file to a higher level or organ with a recommendation as to how it is to be addressed.

3. **Court:** Any one who is not satisfied with the decisions given by Arbitration Committee may try to get solution in Court. A Court decision shall be final and the person in regard to that particular case shall make no further attempt thereafter.

Figure 9.1 below summarizes the suggested grievances handling mechanism.



DNS-Decision not satisfactory

Figure 9.1: Grievance Redress Procedure

10. ENVIRONMENTAL MONITORING PLAN

10.1 GENERAL

The purpose of the environmental monitoring program is to ensure that the envisaged outcome of the project is achieved and results in the desired benefits to Ethiopia, Sudan and Egypt. To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out. The environmental monitoring program provides such information on which management decisions may be taken during construction and operational phases. It provides the basis for evaluating the efficiency of mitigation and enhancement measures and suggests further actions that need to be taken to achieve the desired project outcomes. A draft consolidated environmental monitoring plan for the project is presented which shows the major items to be monitored.

A detailed monitoring plan will be developed alongside a detailed EMP as part of the project's full EIA study and engineering feasibility study in future. The draft monitoring plan, a pro-type of the future final plan, is expected to meet the following objectives for the Mandaya project:

- to monitor the environmental conditions of the Abbay river in Ethiopia, the Blue and Main Nile in Sudan and Lake Nasser in Egypt
- to check whether mitigation and benefit enhancement measures are being adopted, and proving to be effective in practice
- to provide a means whereby any impacts which were subject to uncertainty at the time of preparation of the EIA, or which were unforeseen, can be identified, and to provide a basis for formulating appropriate additional impact control measures
- to provide factual information on the nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

10.2 INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL MONITORING

The principal agencies concerned with both environmental management and monitoring have been introduced in Chapter 9. In brief, they include

- the Project Owner assisted by the project's environment management/monitoring unit (EMU), resettlement management/monitoring unit (RMU) and the Project Owner's Engineer in respect of dam engineering technicalities relating to operations, safety, telemetry and warning systems
- those agencies, on behalf of the project, responsible for construction of transmission lines and associated works (EEPCO, NEC and EEHC), and their environment management/monitoring units (EMUs), and social/resettlement units if different from environmental units (RMUs)

- those agencies, on behalf of the project, responsible for implementing mitigation works in relation to river morphology, river crossings and conversion of flood recession agriculture to pumped irrigation in Sudan (MWRI); and any construction or other mitigation works around Lake Nasser in relation to fisheries, agriculture and navigation
- regional and national environmental protection agencies (EPA, HCENR/SCENR, EEAA)
- all contractors
- Panel of Experts on Dam Safety
- Panel of Experts on Environment and Community Protection

The need to strengthen existing institutions for environmental management, which includes the monitoring function, and to create and support new institutions or units where necessary, has been described in Chapter 9.

10.3 ENVIRONMENTAL MONITORING PLAN FOR MANDAYA

A draft environmental monitoring plan for the whole project is presented in Table 10.1.

The plan is structured according to pre-construction, construction and operational phases.

Monitoring activities in the construction period are classified into monitoring of

- the construction sites and activities and contractor's workforce,
- the bio-physical environment, and
- the socio-economic environment

Thus, in this draft plan, the monitoring of impacts during the construction period are generically covered for construction works in Ethiopia, Sudan and Egypt.

Monitoring activities in the operational period are classified into monitoring of

- the bio-physical environment, and
- the socio-economic environment

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have a detailed Environmental Management Plan, a detailed Resettlement Action Plan and a detailed Environmental Monitoring Plan. The draft Environmental Monitoring Plan here cannot now be completed with respect to details of every impact to be monitored, all locations, frequency of monitoring, responsibilities and costs for each mitigation measure to be monitored. The draft plan (Table 10.1) is restricted to

- mitigation measures to be monitored,
- parameters to be monitored,
- location (all sites, as required, or named particular locations) and
- the kind of monitoring/measurement required

The draft monitoring plan consolidates all monitoring works into one table. This has a practical advantage, for present purposes, of preventing repetition of, for example, monitoring the preserving of top soil, spoil heaps and rehabilitation of works areas at the Mandaya dam site, and at access roads, quarries, borrow areas in relation to Mandaya, transmission line towers and related works in the three countries, and in relation to construction works for river training and converting flood recession areas to pumped irrigation in Sudan, and any construction activities in relation to construction works around Lake Nasser/Nubia.

Similarly, where individuals or a community require compensation for loss of assets and livelihood resources, the need for monitoring disbursement of compensation is described in one row only, recognising that this element is required at one or more sites of project impact in three countries, including sites where mitigation works themselves have socio-economic impacts requiring compensation. In such cases, the location for this universal monitoring requirement is given as “all, as applicable”.

The majority of monitoring will comprise visual observations, carried out at the same time as the engineering monitoring activities. Water quality, noise and air emissions may be monitored qualitatively and quantitatively. Site inspections will take place with emphasis on early identification of any environmental problems and the initiation of suitable remedial action. Where remedial actions have been required on the part of the contractor, further checks will need to be made to ensure that these are being implemented to the agreed schedule and in the required form. Each part of the site where construction is taking place needs to be formally inspected from an environmental viewpoint on a regular basis. The frequencies of monitoring should be indicated during following studies.

In relation to basic physical and biological monitoring, it is important that those responsible for environmental monitoring seek the views of local people and community leaders who live near to the project component since they may be aware of matters which are unsatisfactory, but which may not be readily apparent or recognized during normal site inspections and monitoring visits. There is an obvious overlap here between environmental and socio-economic monitoring and need for regular liaison between those responsible.

There will be merit in coordinating special surveys at Mandaya with those at Roseires. It is envisaged that the routine monitoring and periodic special surveys will contribute to a post-development environmental assessment report for Mandaya and its impact on Roseires and further downstream. As mentioned earlier, decisions on future road communications between Mandaya and Damazin/Roseires may have a significant bearing on the success of this cooperation in management and monitoring at the upper end of the Blue Nile cascade.

With regard to parameters to be monitored, items given in the appropriate column in Table 10.1 cannot be exhaustive at this pre-feasibility stage. The following sub-sections provide limited further description of some of the parameters to be monitored.

10.3.1 Monitoring of construction labour health and accidents

In addition to items listed in the table, parameters that should be monitored include:-

- effective warning procedures and signage for minimizing risks such as visible signs on towers, works areas, and all other hazardous features;
- use of protective clothing, eye goggles, helmets, etc, where appropriate;
- sanitary facilities at campsites;
- awareness of communities about dangers/risks associated with power lines;
- water supply quantities and quality; sanitation condition
- reporting of diseases and accident cases

10.3.2 Monitoring of downstream releases

Regular monitoring of discharge downstream of the tailrace outfall to confirm releases are in line with the Concession Agreement.

10.3.3 Water quality monitoring

Major water quality parameters to be monitored include but will not be limited to major cation and anions, pH, EC, turbidity, colour, NO_3, DO, BOD, COD, grease and oil. Measurement of these parameters should reflect standards set by relevant national government authorities.

10.3.4 Noise monitoring

In addition to blasting operation and permitted times for blasting, there is need to monitor sound levels during construction activities relating to use of heavy machinery and also haulage vehicles for protection of workforce and villagers.

Table 10.1 : Consolidated Environmental Monitoring Plan for Mandaya

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
Pre-Construction Phase			
• In project feasibility and EIA study/ tender documents phase	• Project designs and specifications - incorporate appropriate mitigation and enhancement measures • Appropriate environmental protection clauses specified in contract documents, including non-exceedance thresholds, e.g. for suspended solids in site runoff, air quality, noise; and contractor's monitoring frequency	• For all project sites	
• Abbay watershed management (already on-going)	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Abbay watershed • Abbay river gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
Construction Phase **Contractor's works areas including access roads, quarries, borrow areas, dam, bridges, transmission line towers, stringing, and other construction sites for mitigation works which will disturb the environment in Ethiopia, Sudan and Egypt**			
• Preserve top soil stripped from road edges and construction sites for re-use • Discourage grazing in disturbed area until regeneration has taken place and new growth is firmly established • Erodible surface should be cut only during dry weather where practicable and re-planted as soon as possible	• Stockpiles and their stability • Grazing around disturbed areas • Excavation sites and re-planting	• All, as applicable • All, as applicable • All, as applicable	• Observations • Observations • Observations
• Minimise numbers of spoil heaps; stabilize and re-vegetate them; consider dumping in the reservoir inundation area where practicable	• Spoil disposal and planting	• All, as applicable	• Observations
• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely	• Rehabilitation, restoration and landscaping of used sites; slope stability; access, safety measures	• All, as applicable	• Observations
• Provide adequate sediment settling facilities for particulate matter in drainage from all works sites.	• sediment settling facilities • suspended sediment	• All, as applicable	• Observations and sampling concentrations of treated, non-treated discharges and receiving watercourses
• Ensure toxic compounds are not located near rivers and water points. • Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	• Location of sites • interception and control measures • drip-pans	• All, as applicable	• Observations • Observations • Observations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Provide safe systems for hazardous waste disposal	• Storage and transport of hazardous materials including explosive etc • effluents	• All, as applicable	• Observations • Sampling of effluents
• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	• dust • construction equipment and emissions level • diesel engines	• All, as applicable	• Observations and reports of communities • Observations and reports of communities • Observations and reports of communities
• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	• Blasting schedule and noise • Working hours	• All, as applicable	• Observations and reports of communities • Working hours
• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	• Physical and cultural resources • Works areas	• All, as applicable	• Observations and reports of communities • Observations and reports of communities
• Remove woody material from reservoir area according to recommendations	• EMP recommendations	• Reservoir area	• As per EMP recommendations
• Minimize vegetation clearing for project infrastructure works and rehabilitate sites • Remove potential “eyesores” of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing points	• Vegetation clearing at infrastructure works • Remove of potential “eyesores”	• All, as applicable • Reservoir area	• As per EMP recommendations • Observations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities	• Treatment, removal and disposal of wastes	• All, as applicable	• None – keen observations of contractor's practices
• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures • Liase with RAP officers	• Agreed procedures • Timely warnings • Liaison taking place	• Dam site • Upstream and downstream vulnerable communities • Resettlement office and resettler locations	• Water levels and discharges • Observations and reports of communities • Liaison
• Provide training on environmental protection measures for flora and fauna	• Training for workforce	• Dam site offices	• Compliance with requirements
• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials	• Signage on access roads and project works areas; public roads used as haulage routes	• All, as applicable	• Observations
• Provide appropriate facilities for accommodation and recreation of workforce at dam site camps • Provide appropriate facilities for accommodation at transmission line fly camps	• Accommodation and recreation facilities at dam site camps • Appropriate facilities for accommodation at transmission line fly camps	• Dam site • Transmission line fly camps	• Observations and reports of workforce • Observations and reports of workforce •

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health and occupational safety education for workforce, including education on STDs and HIV/AIDS	• Water supply • On-site health facilities • health and occupational safety; education/training courses; screening; accidents	• All, as applicable • Dam site • All, as applicable	• Water quality testing • Observations and reports of workforce • Records of training; records of health screening; records of health and safety status and site accidents; records of diseases including STDs and HIV/AIDS
• Implement plans for preferential employment of local people, with training	• Staff and labour recruitment procedures • Training/apprenticeships	• All, as applicable	• Records of staff and labour recruitment according to origin • Records of training and apprenticeships provided
• Implement first class communication system and procedures for keeping the public informed about project's progress	• Project communication system	• All, as applicable	• Records of communicated information by different means
• Anticipate, plan and develop infrastructure and other responses for probable induced developments	• Induced developments	• All, as applicable	• Observations, in liaison with regional government and NGOs
Construction Phase **Bio-physical environment in Ethiopia, Sudan and Egypt**			
• Abbay Watershed Management Program	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Abbay watershed • Abbay gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Reservoir slope stability - precautionary measures by contractor	• Reservoir slope stability measures	• Reservoir basin flanks/cliffs	• Observations, followed by SI if required
• Reservoir induced seismicity - precautionary measures by contractor	• Seismicity before and during first filling • Precautionary measures	• Around Reservoir	• Seismograph network records • Observations on vulnerable structures
• Utilise raised groundwater if and where significant for beneficial use • Provide drainage for raised groundwater levels if and where impacts are adverse	• raised groundwater during and after first filling • new springs, or improved flow of existing springs • poor drainage	• Around Reservoir	• Borehole and well records • Spring discharges • Observation of poor drainage
• Disease vectors - provide health care education, clinics and mosquito nets	• Water-related disease vectors • Adequacy of provision of health care education, clinics and mosquito nets	• Around Reservoir • Communities around reservoir	• Observations of vectors • Records of health care education • Records of disease treated • Adequacy of clinics • Records of issued mosquito nets
• Aquatic environment – minimise adverse construction impacts on watercourses by implementation of mitigation measures by contractor during project construction • Implement a reservoir fisheries development program	• All erosion and pollution aspects mentioned above • EMP program recommendations	• All, as applicable • Reservoir and hatchery (in conjunction with surveys and monitoring at Roseires if practicable)	• All observations and measurements relating to erosion and pollution mentioned above • As per EMP, including water quality parameters, phyto- and zooplankton, benthic fauna, fish species, catch per unit effort

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Natural terrestrial habitats and wildlife - minimise adverse construction impacts on habitats by implementation of mitigation measures by contractor during project construction • Avoid damage to any notified habitat sites of special scientific, historical or cultural interest • Implement conservation management measures in reservoir perimeter buffer zone and at environmental offset sites, e.g. Dabus Valley Controlled Hunting Area	• All erosion, pollution, noise aspects mentioned above • Notified habitats • Conservation management measures	• All, as applicable • Reservoir perimeter buffer zone, environmental offset sites, e.g. Dabus Valley Controlled Hunting Area	• All observations and measurements relating to erosion and pollution mentioned above • Observations and reports of workforce • As per EMP recommendations, including surveys/census of water birds and terrestrial wildlife, and surveys of habitats
Construction Phase **Socio-economic environment in Ethiopia, Sudan and Egypt**			
• Provide compensation to affected communities	• Disbursement of compensation	• All, as applicable	• Correct procedures, amounts according to schedules
• Arrange for relocation and settlement of affected people	• Relocation arrangements, and physical and social infrastructure for resettled communities in place	• All, as applicable	• As per RAP recommendations
• Ensure provision of all the necessary facilities in the new settlement area	• Provisions for improved livelihoods for resettled communities in place • Development plan	• All, as applicable	• As per RAP recommendations • As per development plan

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Measures to compensate for lower reservoir levels – power generation	▪ Power generation	▪ In Sudan, Roseires, Sennar, Merowe ▪ In Egypt, High Aswan Dam	▪ Power generation, according to agreed formulae for compensation ▪ Compensation payments
▪ Measures to compensate for lower reservoir levels - fisheries	▪ All measures (e.g. greater stocking with fingerlings, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – agriculture/ pumped irrigation	▪ All measures (e.g. development of new cultivation areas, new pumps, fuel supplies, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – navigation	▪ All measures (e.g. moorings, jetties, pontoons, boats)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ River crossings for pedestrians and livestock, downstream of dam	▪ River crossing places, satisfaction of users	▪ In Ethiopia and Sudan, as applicable	▪ Surveys of use and condition
▪ New irrigation schemes, converted from flood recession agriculture	▪ New irrigation schemes, pumps, areas, satisfaction of farmers ▪ Status of residual areas not commanded by pumping ▪ Water supplies, including mattaras	▪ In Sudan, as applicable	▪ Surveys of measures, satisfaction of affectees
▪ Project induced developments, as anticipated, or as they occur spontaneously	▪ Unknown	▪ All, as applicable	▪ Observations and measurements, as required

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
Operational Phase **Bio-physical environment in Ethiopia, Sudan and Egypt**			
• Abbay Watershed Management Program	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Abbay watershed • Abbay gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations
• Maintenance of rehabilitated surface works areas, including roads, spoil heaps, quarries and borrow areas. Arranging for re-grading, re-planting as required. • Maintain re-vegetation program and discourage unsustainable off-take of woody mass	• Vegetation cover, and public safety • Vegetation cover	• Rehabilitated former works areas • Rehabilitated former works areas	• Surveys • Surveys
▪ Safe transport and storage of all hazardous materials	▪ EMP for hazardous materials storage and transport	▪ All, as applicable	▪ As per RAP recommendations
▪ Waste management for each type of industrial, domestic and sewage waste. ▪ Sanitary engineering at permanent works areas and compounds	▪ All wastes	▪ All, as applicable	▪ Observation on waste storage, treatment and disposal ▪ Monitor effluents and water quality of receiving watercourses and groundwater
▪ Project climatological station and additional rain gauges	▪ Sites and instruments ▪ Climate parameters	▪ All, as applicable	▪ Observe and Inspect sites, instruments and records for quality and continuity
▪ Safety of reservoir banks	▪ Reservoir banks/slopes	▪ Around Mandaya reservoir	▪ Observations, made by boat and land access
▪ New and existing springs, boreholes and shallow	▪ Levels and flows	▪ Around Mandaya reservoir	▪ Observe sites and inspect instruments and records for quality and continuity
▪ Release of water downstream in line with Concession Agreement/ Owner's requirements	▪ Downstream releases	▪ Mandaya Dam	▪ Turbined and spillway flows ▪ Low level and mid level outlet flows as applicable

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Flood forecasting and flood warning scheme	▪ The scheme	▪ Mandaya Dam and downstream	▪ Checking records of past operations; checking equipments and schemes are operational
▪ Mandaya and Border gauging station	▪ Water level , flow and sediment concentration	▪ Mandaya and Border gauging station sites	▪ Checking records of past monitoring; checking equipment is operational ▪ Continuing measurements and calibrations
▪ Mandaya and Roseries reservoirs	▪ Full aquatic/limnological surveys – all hydro-biological aspects	▪ Mandaya and Roseires reservoirs	▪ Surveys, synchronised if possible
▪ Reservoir buffer zone and environmental off set area e.g. Dabus Valley controlled hunting area	▪ Wildlife habitat and wildlife, including contribution to African Water Bird Survey	▪ Mandaya and Roseires reservoirs	▪ Surveys, synchronised if possible
▪ Reservoir sedimentation	▪ Hydrographic survey	▪ Mandaya and Roseires reservoirs	▪ Surveys, synchronised if possible
▪ Environmental protection measures for new roads, housing and industrial developments, etc.	▪ Environmental protection measures	▪ All, as applicable	▪ Surveys
▪ Cooperation between Mandaya project and Roseires reservoirs, contributing information to the power station management's department(s)	▪ exchange of data and information	▪ Mandaya and Roseires reservoirs	▪ Monitor exchange of data and information
Operational Phase **Socio-economic environment in Ethiopia, Sudan and Egypt**			
▪ Resettlement Action Plan and development program(s)	▪ RAP and development plans, and their targets	▪ All, as applicable	▪ Surveys, auditing
▪ Burial grounds, historical or other cultural sites	▪ Burial grounds, historical or other cultural sites	▪ All, as applicable	▪ Surveys, auditing

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Vigilance concerning encroachment of settlements and activities along transmission line Right of Way	▪ Encroachment along transmission line Right of Way	▪ Project high voltage transmission lines	▪ Surveys of any encroachment along ROW
▪ Rural electrification in project areas, as part of development plans	▪ Level of individual and community connections; tariffs; affordability; energy consumption; energy uses, income improvements. Regional development parameters.	▪ All, as applicable	▪ Surveys, auditing
▪ Road communications	▪ Vehicle types, numbers, purposes of travel. Regional development parameters	▪ New Abbay bridge, project roads	▪ Traffic surveys
▪ River and reservoir communications	▪ Condition and uses made of new or improved crossing places of the river and reservoir (ferries, suspended footbridges). Determine areas where needs are not being met.	▪ River and reservoir crossing places	▪ Condition and use surveys
▪ Reservoir and river fishery development	▪ CPUE, fishermen numbers, boats, nets, catches, fish consumption, market prices, fishermen's incomes	▪ Mandaya, Roseires, Blue and Main Nile, Lake Nasser/Nubia	▪ Surveys

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ River training works	▪ Condition of river training works	▪ In Sudan, all as applicable	▪ Surveys of condition
▪ River crossings for pedestrians and livestock, downstream of dam	▪ River crossing places, satisfaction of users	▪ In Ethiopia and Sudan, as applicable	▪ Surveys of use and condition
▪ New irrigation schemes, converted from flood recession agriculture	▪ New irrigation schemes, pumps, areas, satisfaction of farmers ▪ Status of residual areas not commanded by pumping ▪ Water supplies, including mattaras	▪ In Sudan, as applicable	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – power generation	▪ Power generation	▪ In Egypt, High Aswan Dam	▪ Power generation, according to agreed formulae for compensation ▪ Compensation payments
▪ Measures to compensate for lower reservoir levels - fisheries	▪ All measures (e.g. greater stocking with fingerlings, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – agriculture/ pumped irrigation	▪ All measures (e.g. development of new cultivation areas, new pumps, fuel supplies, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – navigation	▪ All measures (e.g. moorings, jetties, pontoons, boats)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Project induced developments, as anticipated, or as they occur spontaneously	▪ Unknown now	▪ All, as applicable	▪ Observations and measurements, as required

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Monitoring Plan. The above table is a proto-type of the future Environmental Monitoring Plan; it cannot now be completed with respect to location, frequency, responsibilities and costs for each mitigation measure to be monitored. Many of these are unknown at pre-feasibility stage. Lumped cost estimates of monitoring are included in Chapter 11.

10.4 RESETTLEMENT ACTION PLAN AND DEVELOPMENT

The draft consolidated monitoring plan purports to cover project monitoring generically, and is necessarily light concerning RAP. Resettlement and associated development is a very important component of the project and a few additional points are made here.

When construction contracts are awarded, the contractors will require all land acquisition to be completed and to have freedom to get on with construction works. Schedules for moving out of works areas, including provisions for vulnerable groups, will be incorporated in RAP plans produced during feasibility studies for the Mandaya dam area and, as may be required, for the transmission lines. The RAP plans for these will also cover items concerning compensation, compensation disbursement, restoring and improving livelihoods, training, infrastructure and social services.

Implementation of RAP plans requires monitoring by agencies described earlier.

The items to be monitored in the construction phase will be scheduled in detail in RAP plans. Some are anticipated and summarised in Table 10.2. In consultations with local people and community leaders, those monitoring will ensure that these are satisfactory, or developing to a foreseeable satisfactory condition, for all PAPs without exception.

Table 10.2 : Socio-economic Monitoring for Resettlement

Items to be monitored before resettlement	
(1)	Disbursement of compensation which should take place promptly and according to agreed rates
Items to be monitored at resettlement sites (community gains)	
(2)	New houses
(3)	New housing suitable for all kinds of livestock
(4)	Universal availability and use of mosquito nets
(5)	Water supplies, quantity and quality
(6)	Sanitation provisions
(7)	Drainage arrangements
(8)	Roads and footpath networks
(9)	Clinics, and qualified health care staff numbers
(10)	Schools, and qualified teaching staff
(11)	Community buildings and facilities, including market places
(12)	Energy sources
(13)	Shade trees

Livelihood conditions to be monitored at resettlement sites	
(14)	Provision of health care facilities, and monitoring numbers of diseases cases, especially STD and HIV
(15)	Family incomes, and their meeting targets
(16)	Vulnerable groups
(17)	Agricultural production
(18)	Tree production
(19)	Livestock production (chickens, goats, sheep, cattle, donkeys) and grazing resources
(20)	Fish, honeybee, and non-timber forest products and related activities.

Those monitoring (regional government departments and RMUs) will seek to ensure that livelihoods of resettled PAPs are re-established rapidly, and improving. The RMUs will also be responsible for ensuring on-going provision of satisfactory veterinary, agricultural, horticultural and other specialist advisory and treatment services in host/resettlement villages.

At intervals, independent auditing and monitoring will be required for all host and resettled communities. Targets set in the RAP and development plans, and as may be subsequently revised, must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to the independent Panel of Experts for the Environment and Community Protection, local communities and local administrations, government, NGOs and project financiers.

Where such monitoring reveals failures to achieve targets, measures should be taken to improve conditions immediately. It is suggested that financial provision for such contingencies to mitigate and improve conditions should be made available from Mandaya project's income stream, over and above annual allocations of project funds, unless other arrangements are in place.

11. PRELIMINARY ENVIRONMENTAL COST ESTIMATES

11.1 COST ESTIMATES IN ETHIOPIA

The environmental cost estimates address unavoidable negative impacts that will take place during the project's construction and operation. These impacts are generally categorized into physical, biological and socio-economic as described in Chapter 6.

Tables 11.1 and 11.2 provide summaries of cost estimates in Ethiopian and US dollar currencies, respectively. The exchange rate adopted is 1 USD = ETB 9.21. The following notes refer to rows in these tables.

1) ***Reservoir Clearing:*** Cost of removing most biomass (vegetation) from the reservoir inundation area. The estimated cost is shown here but included in civil engineering cost estimates.

2) ***Technical Environmental Optimization:*** Additional cost that may be necessary to cater for environmental concerns during the detailed design

3) ***Compensation or Annual Crops:*** Compensation for lost rainfed production from arable land (maize and sorghum are the dominant crops under rainfed farming) in construction areas – roads and other works

4) ***Compensation for Annual Crops:*** Compensation for lost production from recession agriculture (in addition to maize and sorghum, etc., vegetables, tobacco, and others) in reservoir area and in Sirba Abbay villages

5) ***Compensation for Grazing Land:*** Compensation for lost grazing area by the community.

6) ***Compensation for Lost Natural Resources:*** Compensation for lost production from natural resources inundated (honey, hunting, fish).

7) ***Implementation of livelihood safeguard program:*** Cost of income generation projects introduced to ensure that directly affected people and communities are not disadvantaged by the project and have access to viable income generating opportunities in the resettlement areas.

8) ***Compensation for houses/assets:*** Cost of replacing houses/assets lost in the reservoir area and in works areas.

9) ***Transmission Lines***: Compensation for impacts of project transmission lines from Mandaya to Sululuta and to Hasaheisa/Rabak.

10) ***Fisheries study/outreach program:*** Fisheries development outreach support (taking into account present and future fishery potential through study, training and capacity building)

11) ***Health Centre (health personnel and associated employees):*** Contribution to upgrading health facilities for local project employees, their families and other local people. This is separate from the contractor's obligations and to help counteract the likely health problems associated with the construction workforce. A health awareness campaign (focusing on HIV, STD's an other transmittable diseases) should be initiated, free condom distribution to workers, volunteer testing and counseling would be part of the cost.

12) ***Replanting:*** Cost of replanting areas disturbed and ensuring that woody biomass is replaced where possible (focus will be given to restore vegetation species that have significant ecological and economic importance)

13) ***Generic Best Management Practices for Disturbed Area:*** Remediation of areas disturbed/contaminated by construction activities, including locations exposed to increased risk of erosion, over and above responsibilities of the contractor. (Primarily focus on conservation oriented construction; physical conservation may be included as required)

14) ***Conservation Initiatives:*** Cost of further surveys of flora and fauna in the direct impact zone, plus funds for propagation if applicable. (Priority will be given to develop conservation areas and environmental offsets).

15) ***Water Quality Monitoring:*** Cost of checking water quality in the reservoir and downstream of the tailrace outlet, over and above the contractor's obligations.

16) ***Monitoring of Construction Work:*** Monitoring/auditing construction and adherence to the EMMPs. EMU.

17) ***Socio-Economic Monitoring:*** Cost of ensuring effective implementation of the livelihood safeguard program and providing services to redress grievances; cost of monitoring disbursements under the compensation/mitigation program and the health status of the local community, etc. RMU.

18) ***Institutional Capacity Building Program:*** Institutional capacity building for local institutions to cope with the modalities of a large construction project in their locality and support to national agencies responsible for advising on and inspecting aspects of implementation including environmental mitigation projects (Special attention to strengthening the newly established Environmental Protection Authorities in Benishangul Regional and Amhara).

19) ***Community Gain:*** Contribution to health, water supply, sanitation, schools/education, veterinary services, etc to be decided by the resettled people from the direct impact zone.

20) ***Post Construction Environmental Audit*:** One time cost of checking the construction site remediation after the contractor has left (final payment of contractor will be tied to a successful audit inspection).

21) ***Compensation for Downstream Flood Recession Agriculture:*** This refers to an estimated 2,400 ha of cropped land which will no longer receive Abbay's annual flood during and following impoundment. Compensation is for 10 years' production.

22) ***Compensation for Downstream Gold Panning:*** This refers to loss in resources and opportunities for gold panning when Mandaya traps sediment and raises dry season flows in the Abbay river channel. Compensation is for 10 years' losses.

Table 11.1 : Mandaya Environmental Cost Estimate – ETB

No.	Item	Text Reference	Units	Quantity	Unit Cost ETB	Capital Cost ETB	Recurrent Cost Lump Sums ETB	
							Construction Phase	Operational Phase
1	Reservoir Clearing (costed as Civil Work)	Table 6.3	ha	66,100	5,526	365,268,600		
2	Technical Environmental Optimization	See Note	LS			1,800,000		
3	Compensation for annual crop (10 yrs)	Table 6.5	ha	94	25,149	23,640,060		
4	Compensation for annual crops (10 yrs)	Section 6.5.6 and Table 6.8	LS			40,000,000		
5	Compensation for grazing land (10 yrs)	See Note	ha	4,653	150	6,979,500		
6	Compensation for lost Natural Resources (10 yrs)	Table 6.9	HH	324	2,967	9,612,000		
7	Implementation of livelihood safeguard program	See Note	Persons	1,620	2,500	4,050,000	850,000	1,800,000
8	Compensation for houses/assets	Table 6.4	Houses	600	972	583,200		
9	Compensation for Transmission Lines	Table 6.7	LS			40,524,000		
10	Fisheries study/outreach programme	See Note	LS			1,800,000		180,000
11	Health centre (project employees & locals)	See Note	LS			450,000	50,000	
12	Replanting	See Note	ha	200	4,950	990,000		
13	Generic BMP for disturbed areas	See Note	ha	400	7,200	2,880,000		
14	Conservation initiatives (provisional sum)	See Note	PS	2	675,000	1,350,000		
15	Water quality monitoring	See Note	LS				90,000	40,500
16	Monitoring of construction work	See Note	Year	10	270,000	2,700,000	1,080,000	
17	Socio-economic monitoring	See Note	Year	10	20,000	200,000	1,800,000	
18	Institutional capacity building program	See Note	LS			4,500,000	900,000	50,000
19	Community gain	Table 6.10	LS			1,716,987	1,800,000	100,000
20	Post construction environmental audit	See Note	LS			720,000		
21	Compensation for downstream recession agriculture	Section 6.5.26	LS			64,836,000		
22	Compensation for downstream gold panning	Section 6.5.26	LS			21,600,000		
	Sub-Totals (excluding reservoir clearance)					230,931,747	6,570,000	2,170,500
	Contingency at 10%					23,093,175	657,000	217,050
	Grand Total (ETB)							**263,639,000**

Table 11.2 : Mandaya Environmental Cost Estimate - USD

No.	Item	Capital Cost USD	Recurrent Cost (USD) Construction Phase	Recurrent Cost (USD) Operational Phase
1	Reservoir Clearing (included in Civil Works)	39,660,000		
2	Technical Environmental Optimization	195,440		
3	Compensation for annual crop (10 yrs)	2,566,782		
4	Compensation for annual crops (10 yrs)	4,343,105		
5	Compensation for grazing land (10 yrs)	757,818		
6	Compensation for lost Natural Resources (10 yrs)	1,043,648		
7	Implementation of livelihood safeguard program	439,739	92,290	195,440
8	Compensation for houses/assets	63,322		
9	Compensation for Transmission Lines	4,400,000		
10	Fisheries study/outreach program	195,440		19,540
11	Health centre (project employees & locals)	48,860	5,430	
12	Replanting	107,492		
13	Generic BMP for disturbed areas	312,704		
14	Conservation initiatives (provisional sum)	146,580		
15	Water quality monitoring		9,770	4,400
16	Monitoring of construction work	293,160	117,260	
17	Socio-economic monitoring	21,716	195,440	
18	Institutional capacity building program	488,599	97,720	5,430
19	Community gain	186,426	195,440	10,860
20	Post construction environmental audit	78,176		
21	Compensation for downstream recession agriculture	7,039,740		
22	Compensation for downstream gold panning	2,345,280		
Sub-Totals (excluding reservoir clearance)		25,074,026	713,350	235,670
Grand Total (USD) including 10% contingency				**28,625,000**

The estimated provisional sum of USD 28.6 million is for mitigation in the direct impact zone in Ethiopia (including the Mandaya transmission lines in Ethiopia and Sudan) and for downstream mitigation in Ethiopia. With an estimate of USD 39.7 million for reservoir basin clearance, these environmental costs (USD 68.3 million) represent some 2.8% of the estimated overall project cost (USD 2,472 million)[1].

[1] It is may be noted that the estimated overall project cost (Table 3.11) provided for a lower figure of environmental mitigation, USD 22 million, and this was included in the project model for investment planning and modelling (Module 6). This subsequent revision by some USD 6.6 million is believed inconsequential at this pre-feasibility stage of planning, given the adopted large reservoir clearance area that is likely to be unattainable and cost less in practice, and the large contingencies provided for in overall project costs.

11.2 COSTS AND BENEFITS IN SUDAN AND EGYPT

In this initial environmental examination of the project, it has been possible to make assessments of the compensation and socio-economic mitigation costs of the Mandaya project and transmission lines, and to include some allowances for management and monitoring in Ethiopia, as described above.

It has not been possible to estimate the costs and benefits of each and every mitigation and enhancement measure in Sudan and Egypt, nor of the management and monitoring costs. These measures and needs are scoped but insufficiently defined and studied to permit cost estimation, and are beyond the scope of this study.

Where some indication of costs and benefits in Sudan are available, they have been mentioned in the report. They are summarised in Table 11.3, along with text references. Although incomplete in many areas, a value of the table is that it reveals the very considerable areas of study required in Sudan and Egypt in future to ascribe downstream costs and benefits to upstream storage projects in Ethiopia.

Table 11.3 : Project Costs, Downstream Benefits and Mitigation Cost Areas

Text Reference	Project and Downstream Impacts	Benefit USD million	Cost USD million
Table 3.11	Mandaya Project Cost		2,472
7.6.1	Potential sale **value of the electricity** generated at Mandaya - firm energy only	448 / year	
7.6.2	The annual sale of the **uplift of energy** in Sudan	88 / year	
7.6.3	**River morphology changes**, river training works	-	Not assessed
7.6.4	**Incremental fisheries production**	Not assessed	-
7.6.5	**Additional irrigation with regulated flows**	Not assessed	
7.6.6	**Reduction in flooding – health services, urban, property, infrastructure**	< 52 / year	-
7.6.6 Table 7.15 Table 7.16	**Reduction in flooding – pumped irrigation as mitigation for reduction of recession agriculture** Benefits and costs 434,700 feddan conversion	Not assessed	(1) 1,739 (capital and annual combined) (2) 2.9 (annual for energy)
7.6.7	**Reduction in reservoir sedimentation**. Benefits claimed in energy uplift above	-	-

Text Reference	Project and Downstream Impacts	Benefit USD million	Cost USD million
7.6.8 7.6.9 Table 7.17	**Reduction in reservoir sedimentation**. Foregone agricultural production	230 to 316 / year	-
7.6.8	**Reduction in sediment loads at abstraction points and irrigation schemes** Desilting of 17,244 km of irrigation and 10,650 km of drainage canals in the Gezira-Managil scheme (1997-98 estimate)	5.87 / year	-
7.6.8 Table 7.18	**Reduction in sediment loads at abstraction points and irrigation schemes** Rahad and Gezira-Managil Irrigation Schemes - Estimated Present Value of Sediment and Weed Clearing Costs (NPV)	46.26	-
7.6.8	**Reduction in reservoir sediment loads at abstraction points and irrigation schemes** Reducing high costs of water purification	Not assessed	-
7.6.8	**Reduction in reservoir sediment loads at abstraction points and irrigation schemes** Pump damage	Not assessed	-
7.6.9	**Reduction of sediment loads** Use of artificial fertilizers	-	Not assessed
7.6.10	**River crossings on Blue Nile** Navigation benefits and pedestrian/livestock river crossings	Not assessed	Not assessed
7.6.11	**Reduction in evaporation at HAD** Additional water supplies Foregone energy	Not assessed	Not assessed
7.6.12	**Reduced level of Lake Nasser/Nubia** Fisheries, agriculture, navigation	-	Not assessed
7.6.12	**Reduced level of Lake Nasser/Nubia** Reduced power generation at Aswan	-	Not assessed

11.3 PROJECT'S FINANCIAL CONTRIBUTION TO ABBAY WATERSHED MANAGEMENT

The pre-feasibility engineering report and this report (Chapter 4) has produced, from very limited data in 2004, high estimates of sediment transport in the Abbay. The presentation of these estimates at the workshop in Khartoum in June 2007 shocked participants. These alarming estimates are not confirmed and may be unrealistic. Nobody can confirm or deny these new estimates because sediment transport has not been, and is not being, monitored comprehensively. These new estimates cause great concern.

In Section 6.3.4, it was stated that the Mandaya project could, and it is believed should, have a very significant role to play in the watershed management program for Abbay and that the Abbay watershed management program is required regardless of the Mandaya project. It was suggested that the mechanism for the Mandaya project contributing to watershed management could be through its financial support from energy sales. Thus, a watershed management cost requires to be incorporated in Mandaya environmental cost estimates. Currently, a reasonable quantification of this cost – as with other cost and benefit items, particularly those listed in Section 11.2 – is beyond the scope of this study and this is noted as a requirement in future work. The following points convey some of the complexity of this issue.

Watershed management reports for the Eastern Nile have been drafted but have not yet developed into watershed management plans for sub-basins (and micro-catchment areas) with associated cost estimates which are apportioned to farmers and other land-users and government. It is understood that the issue of land ownership is a sensitive issue in Ethiopia and that security of land tenure is or may be critical for farmers and other land-users to implement soil conservation measures, and then maintain them, knowing that the results of their efforts may be enjoyed by their descendants. Apart from soil conservation measures on family land holdings, there is the issue of arresting sheet, rill and gully erosion on common land for which no individual is responsible and for which major civil engineering and bio-engineering works are required – completely beyond the capacity of local communities. In this regard, some good works may be carried out on individual land holdings but these may in practice become useless because of no measures being taken upslope. There are many more issues, including those relating to community participation in adoption and acceptance of soil conservation measures and grazing control, and ongoing pressure from increases in rural populations. The scale of the erosion and reservoir siltation problem is huge and the cost of simultaneously arresting land degradation and improving land use may probably be estimated to run into scores or hundreds of millions of dollars.

12. CONCLUSIONS

12.1 PRELIMINARY SCREENING

12.1.1 Power, land and population displacement

The energy produced by the 2000 MW Mandaya project (12,119 GWh/year) is very substantial. Screening the project by considering the land area flooded (736 km^2) and the numbers of people displaced (600) by the reservoir for each installed MW suggests that Mandaya is favourable in comparison to many of the major hydropower developments in the world. Plots of these two indices are shown together with those for other major dams listed by IUCN/World Bank (1997) in Figure 12.1.

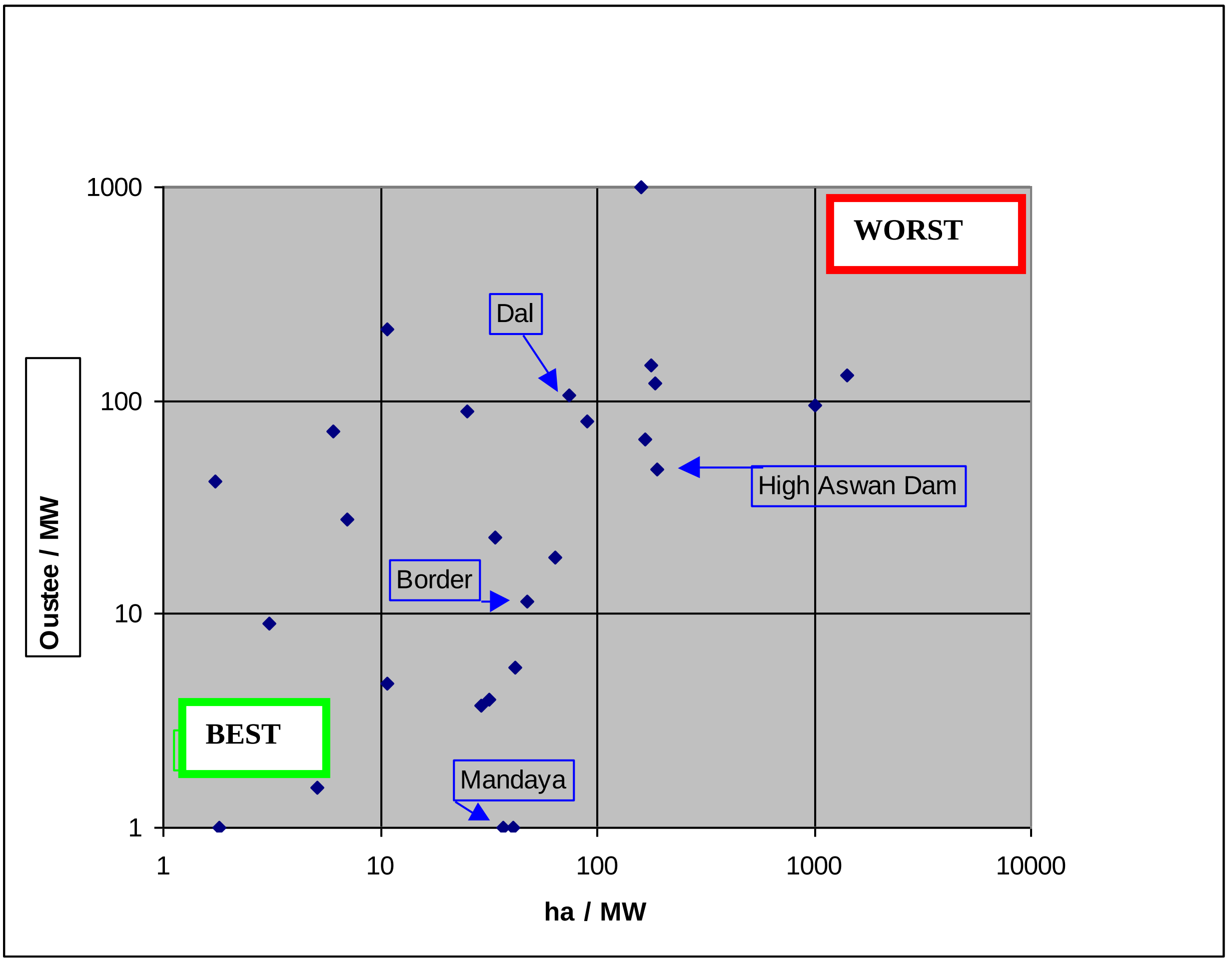


Figure 12.1: Hydropower Efficiency Ratios

Taking a global view, with an index of less than one person per installed MW it has to be concluded that Mandaya must be one of the few remaining potential major hydropower project sites in the world where development would disturb so few people directly.

12.1.2 Downstream energy generation uplift

Mandaya is located upstream of an existing hydropower cascade in Sudan and Egypt (Roseires, Sennar, Merowe, High Aswan Dam). By virtue of its location and function of regulating flows, and by trapping and reducing rates of reservoir siltation downstream, it is estimated that the uplift in energy at the hydropower stations in Sudan will be in the order of 2,211 GWh/year. This additional hydro energy can be produced in Sudan without additional capital expenditure, without inundating more land and without displacing any population. It is concluded that this is a very valuable secondary benefit of the Mandaya project.

12.1.3 Water conservation

Ten riparian countries share the Nile river system and demands on the river are high and increasing. The population in the desert in the north of Sudan and almost the whole population of Egypt are totally dependent on the river for water supplies and irrigated food production, not to mention the river's importance to these countries for power generation. Whilst all reservoirs in the region cause loss of precious water resources through evaporation, reservoirs in the wetter and cooler highlands of Ethiopia offer least evaporation losses. Figure 12.2 shows the amount of annual evaporation losses per installed MW and per GWh/year for Mandaya and Border in Ethiopia and Dal in the Nubian desert in Sudan. Mandaya's evaporation losses for each unit of electrical energy are nine times less than at Dal.

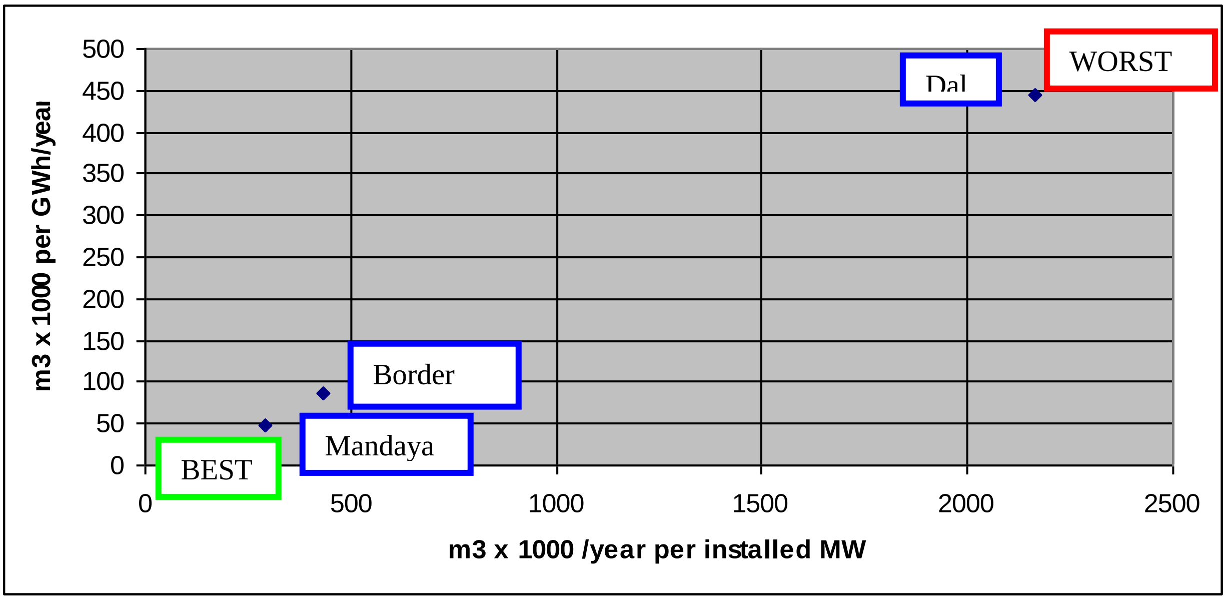


Figure 12.2 : Hydropower Efficiency Ratios of Annual Evaporation Losses for Installed Capacity and Annual Energy

12.1.4 Conclusions on Preliminary Screening

It is concluded that development of Mandaya on the Abbay in Ethiopia is very favourable from the point of view of primary and secondary energy benefits, minimising population displacement and conserving water resources in the water constrained Nile system where demands continue to increase.

12.2 PRINCIPAL ENVIRONMENTAL IMPACTS AND MITIGATION

The primary and secondary energy benefits, and the water conservation benefit of Mandaya are outstanding for the Eastern Nile region. They are associated with many other benefits, especially in Sudan, and with a number of disadvantages in Ethiopia, Sudan and Egypt. This pre-feasibility has scoped and considered many issues but all of these require more detailed studies in line with Mandaya having a Category "A" status and therefore in need of a comprehensive environmental impact assessment study. Conclusions about the principal impacts are described below.

12.2.1 Resettlement

The anticipated resettlement associated with the Mandaya project may be regarded as small for the size of project but it will nevertheless be a very important component of it. Land resources and socio-economic surveys will be required in order to propose a Resettlement Action Plan associated with a development plan for host and resettled communities.

As population density in the region is low, and annual rainfall is somewhat greater than 1,000 mm, there is a good prospect of comprehensive planning, in full consultation with the Benishangul Gumuz and Amhara state authorities, determining resettlement sites conducive to sustainable villages and improving social services and people's livelihoods. There are three additional favourable factors. Firstly, Benishangul Gumuz has already listed some 38 potential resettlement sites, regardless of this project; some of these sites may be suitable for the Mandaya project's resettlement needs. Secondly, public participation during this study's socio-economic surveys revealed that both regional government officers and rural communities consulted are in favour of the project, believing it will improve the road network and be a catalyst for development and employment in the region. Thirdly, the successful resettlement program for the recent Gilgel Gibe hydropower project is a helpful precedent for building confidence and trust in resettlement planning for other hydropower projects in Ethiopia.

12.2.2 Physical Cultural Resources

Although the Nile valley as a whole is renowned for its historical heritage, preliminary literature surveys of the Mandaya area have revealed few sites of interest and none in the project area itself. There is not a single road in the reservoir area which is testimony to its isolation and suggests that the gorge-like valley has always been inhospitable in a region where plateau tops and undulating valleys are abundant in the surrounding areas. Nevertheless, more detailed consideration of the existence of physical cultural resources will be required.

12.2.3 Terrestrial Ecology

The project area is dominated by deciduous woodland habitats. Preliminary field surveys and documentation have indicated no terrestrial plant or animal species endemic to the area. Detailed surveys will be required to improve the available baseline data and provide much more certainty about the presence/absence of threatened and vulnerable species so that impact assessment may be improved. Such surveys should include biomass and soils so that reservoir water quality modelling may assist planning of the amount of reservoir basin clearance which will be needed to avoid or minimise potential water quality problems in Mandaya reservoir and in its releases downstream. Surveys may be expected to take at least two years.

12.2.4 Aquatic Ecology

Preliminary field surveys and documentation have indicated no aquatic plant or animal species endemic to the area. A good data set exists for Roseires reservoir downstream. Detailed surveys will be required to improve the available baseline data and provide much more certainty about the presence/absence of threatened and vulnerable species and fish migration so that impact assessment may be improved and a fisheries development program may be proposed. Surveys may be expected to take at least two years.

12.2.5 Mineral Deposits

Assessment of the geology of the reservoir basin by the project geologist did not reveal the known occurrence of existing, or potentially, commercially valuable mineral deposits. The situation about alluvial gold, originating from diverse sources, is described in the report. Also, commercially exploited marble deposits exist in the region near the project reservoir but are not worked in the reservoir basin. However, because of the difficulties of access to the reservoir basin, it is possible that valuable mineral deposits exist. If so, the opportunity cost of inundating such resources should be assessed. Before or in future studies, this aspect needs to be pursued further and clarified as much as possible. In particular, any historical or existing prospecting concessions which have been awarded should be traced and discussions held with the Ministry of Mines and Energy, the Ethiopian Institute of Geological Surveys, the Ethiopian Mineral Resources Development Corporation and the Ethiopian Investment Authority, and mining companies which have been or may be active in the region.

12.2.6 Reservoir First Filling

The proposed storage capacity of Mandaya reservoir is very large (49 billion m^3). First filling necessarily causes reduced flows and power generation downstream. Owing to the very large storage capacity at High Aswan Dam, which in all but the most severe hydrological sequences provides a buffer against water shortages in Egypt, it appears that Mandaya may be filled without causing water supply shortages for public water supply and irrigation. A number of simulations have been carried out but many more, using agreed data sets and variants of these, will be required to assess the downstream impacts of first filling on power generation in Sudan and Egypt, and on fisheries, irrigated agriculture and navigation at Lake Nasser/Nubia.

The mitigating measures and cost of mitigating the impacts of first filling require much greater examination in following studies.

12.2.7 River Morphology

With retention of most of the sediment load in Mandaya reservoir, the released turbined and spillway water will have greater energy and changes in river morphology may be expected in the Blue and Main Nile. River training and bank protection works are expected to be needed. A river morphology study is required to assess potential impacts and identify vulnerable locations in order that mitigation works may be proposed and cost estimates produced.

12.2.8 Flooding and Recession Agriculture

Simulations of Mandaya reservoir behaviour and turbined releases and spillway flows suggest that the annual flood of the Blue Nile and Main Nile will be severely reduced. This would have major benefits for reducing urban flooding and related disruption along the Blue and Main Nile, at parts of Khartoum and Dongola in particular. This flood damage relief would be welcomed. However, the annual flood supports life along the river through the desert to Lake Nasser/Nubia, providing overbank water supplies for flood recession agriculture and other vegetation, and re-charging groundwater. It also deposits silt regarded by farmers as an annual dressing of fertilizer. The proposed mitigation for this impact is to convert these areas to pumped irrigation, and for artificial fertilizers to be used as necessary. It is concluded that a comprehensive study of these issues is required, leading to engineering and agricultural proposals for the mitigation works and estimates of costs and benefits to be ascribed to the Mandaya project. It is also concluded that this conversion would need to be implemented before first filling of Mandaya begins in order to prevent hunger and hardship for the affected communities.

12.2.9 Secondary benefits in Sudan

The secondary benefits of the Mandaya project in Sudan result from the project raising dry season flows very substantially and reducing sediment transport. These benefits relate to power generation, irrigation and water supplies including the reduction of maintenance and water treatments costs. These benefits require greater study in order to estimate the benefits quantitatively and include them, along with other costs and benefits, in economic and financial studies of Mandaya.

12.2.10 Lake Nasser/Nubia

Several thousand people depend on fisheries, lake recession and irrigated agriculture, and navigation in the Lake Nasser/Nubia area. Development proposals indicate that greater settlement will take place in future to exploit the available resources in the region. The first filling reduction in lake levels caused by Mandaya, and, after recovering levels, the prolonging of low levels in droughts (when Mandaya is refilling) will impact on livelihoods and the local economy, and power generation at Aswan. It is concluded that detailed studies will be required to assess impacts and make proposals to address them with cost estimates.

12.2.11 Watershed Management

The long-term sustainability of power generation at Mandaya will be impaired by reservoir siltation. As the project's yield is reduced, the secondary benefits of the project in Sudan and Egypt will be reduced. It is concluded that proposals for watershed management in the large Abbay river basin, which are under development, need to be completed and implemented as soon as practicable and that it will be in the interests of the three countries that the watershed management program is boosted by addition funding from the income stream of the Mandaya project when it becomes operational.

12.2.12 Dam Safety

Mandaya's 200 m high dam, and its storage contents, is large by any standard. There will be need for every precaution to be taken in its design, operation and maintenance and for all relevant information to be known to the public. For this it is concluded that the project will require an international Panel of Dam Safety Experts.

12.2.13 Environment and Community Protection

The Mandaya project will have many benefits but also adverse impacts in three countries requiring mitigation. Some of these mitigation measures are themselves development projects on a large scale. Because of the complexities and wide-ranging nature of these impacts and mitigation measures, it is concluded that the project will require an international Panel of Experts for Environment and Community Protection.

12.2.14 Public Relations, Communications and Grievances

The construction of the Mandaya project is expected to take ten years. Works to mitigate adverse impacts are many, including resettlement, river training, conversion of flood recession agriculture to pumped irrigation and possibly some works at Lake Nasser/Nubia. Thus the opportunities for grievances will be many. Because of the project being developed and having impacts on three countries, it is concluded that a first class communications system will be required to inform stakeholders of plans, changes in plans and progress, and that procedures for dealing with grievances will be required to be developed and made widely known. This aspect requires attention and priority in future project studies.

12.3 THE WAY FORWARD

It is clear that a comprehensive EIA study will be required in parallel with engineering feasibility studies. Experience of conducting this initial environmental impact assessment has suggested the following important conclusions.

12.3.1 Rehabilitation of Border gauging station

The river gauging station at Border downstream of Mandaya is vital for feasibility and EIA studies. Although the river section is in rock and the stage/discharge relationship is understood to be stable, there have been no sediment transport measurements during the annual flood for over 40 years. Sediment sampling is impracticable because the cableway and the cable car are unsafe for hydrologists and unserviceable. As this station is relevant to determining the flows available at Mandaya for power generation, and the siltation rate of the reservoir which will reduce the power generation, and the station may be a key control point for monitoring flows in a Concession Agreement or other legal instruments for the Mandaya project, it is essential that works are carried out to rehabilitate this station.

The recent 2007 annual flood should be the last flood passing through this station without sediment concentrations being measured on a regular basis. Rehabilitation works, and any new gauging equipment, are required to be in place and operational by June 2008.

This urgency is further emphasised by the imminent demise of the El Deim river gauging station in Sudan, a few kilometres downstream. This station’s cableway has also not been operating for many years but its rehabilitation or replacement is understood to be impracticable because of plans to raise Roseires dam.

Because the continuous presence of a gauging team will be required at the Border station in the annual flood season in future, the rehabilitation of the station should also include provisions to accommodate all gauging staff comfortably. Thus, permanent housing, stores, furniture, lighting and related facilities to ensure health and safety of the gauging team will be required.

12.3.2 Components of full EIA study – level and timing of sub studies

Some of the proposed mitigation measures for the Mandaya project are substantial projects. Progress in EIA procedures over the last 20 years has recognised this in relation to resettlement in particular, and it is now common to conduct comprehensive cultural/agricultural/socio-economic studies of potential resettlement areas and resettlement almost as stand-alone projects. Such studies produce RAP reports which are then integrated into EIA reporting. This procedure is satisfactory.

For the Mandaya project, other important sub-studies are required in Sudan (river morphology, conversion of flood recession agriculture to pumped irrigation, quantifying benefits of regulated flows and reduced sediment loads) and in Egypt (exploring by simulation modelling and fieldwork the impacts of first filling and operations on Lake Nasser/Nubia in terms of energy, fisheries, agriculture, navigation and evaporation losses).

As each of these sub-studies and developments will have a significant role in determining the design and the costs and benefits of Mandaya, and ultimately the negotiated ownership and investment of the project, there may be merit in proceeding with some of them, or components of them, in advance of engineering site investigations and feasibility studies. Each of these studies will inform others and assist the engineering design.

Thus the standard procedure for hydropower projects of arranging for all study components to be addressed simultaneously during engineering and EIA studies, over a period of say two years, may be inappropriate in this case of a major project on an international waterway.

It is concluded that wisdom is required in building confidence and trust in all stakeholders, and that various components (e.g. converting annually flooded areas – expected by people for millennia – to pumped irrigation) may need further examination with full public consultations before committing resources to studying all components together. In other words, a phase of pre-feasibility studies of mitigation (and enhancement) projects may be required in order to establish more clearly whether the mitigation projects themselves will be culturally acceptable and feasible.

These pre-feasibility studies of mitigation works are likely to identify gaps in data availability which will need addressing before they are studied at feasibility level. For example, irrigation along the Blue and Main Nile, to replace the annual flood, is certain to require topographic mapping at a suitable scale for designing irrigation layouts and such mapping may not be available in many areas. River morphology studies would benefit from a pre-feasibility study before considering the finally proposed regulated hydrology – which can only emerge from a comprehensive series of simulation studies, mainly in relation to Lake Nasser, at a later date.

It is therefore concluded that very serious thought is given to preparing the levels and sequencing of future studies for the Mandaya project.

Draft Terms of Reference for future studies are given in Appendix 12.

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Tahal, in association with MWH (Chicago) and Concert Engineering and Consulting Enterprise PLC (Ethiopia)	2006	Ethiopian-Nile Irrigation and Drainage Project. Consultancy Service for Identification of Irrigation and Drainage Projects in the Nile Basin in Ethiopia. Revised Final Report. Report, dated July 2006. MOWR.
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Author	Year	Publication
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APPENDICES

Appendix 5.2 Flood Damages in Sudan

Appendix 6.1 Mandaya Hydropower Project – CO_2 Emission

Appendix 6.2 Compensation Procedures in Sudan and Egypt

Appendix 12 Terms of Reference for Environmental Impact Assessment of Mandaya project

Appendix

Contributors to Initial Environmental Impact Assessment of Mandaya and Border Hydropower Projects

Team members in Ethiopia (Tropics. 251-011-5514393; tce@ethionet.et)

Ato Zelealem Abebe	Team Leader
Dr. Abebe Getahun	Aquatic ecology
Dr. Tamirat Bekele	Terrestrial ecology
Ato Mekuria Asfaw	Public Health
Ato Bantealem Taddesse	Archaeological/Cultural
Ato Lemma Eshetu	Socio-economics

YAM Consultants, Khartoum

Mr. Mustafa Babiker	Policy, Legal and Administrative aspects in Sudan
Dr. Asim El Moghraby	Ecologist

Remote Sensing Authority, Khartoum

Dr Amna Hamid	Satellite imagery analysis along Blue and Main Nile

Scott Wilson Contributors

Andrew Wain	Co-ordinator and editor; river regulation; downstream assessment
Edda Ivan-Smith	Resettlement
Alan Bates	Engineering, carbon assessment
Terry Page	Geology, minerals, seismology, slope failures

Appendix

Record of Environmental Consultations on Mandaya and Border Projects

Consultations during Inception Mission in Ethiopia, 21st to 31st October 2006		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Addis Ababa**
21/10/06	Dr. Babiker Ibrahim (ENTRO)	Emphasis on obtaining primary field data. First observations of 1:50,000 maps with indicative reservoir levels 600 m at Border and 800 m at Mandaya.
24/10/06	**Ato Yonas Teklemichael**, EIA specialist, EPA	Discussion on project and limitations of initial environmental assessment for pre-feasibility engineering studies. Full EIA and RAP are not required and not possible. Policy, legal and administrative chapter in recent E-S power system interconnection ESIA study is useful. Very clear that scoping report must present as much primary data as practicable, including through listening surveys. Agreed that it is not appropriate to ask potential resettlement interviewees about preference for cash or land for land – this is at full feasibility stage. Premature to unsettle people at scoping stage when 3 projects being considered. Scoping reports must provide full TORs for EIA studies.
24/10/06	Geremew G/Selassie and Tayech Ourgicho Editors of Tefetro, EPA	Soil conservation and education needs. Abbay delivery of 100 Mt/y to cripple Roseires reservoir. Obtaining copies of Tefetro magazine, including the magazine issue with interview with Ato Yonas Teklemichael (EPA) re EIA procedures.
25/10/06	**Kinfe Abebe & Mengistu Wondafrash**. Ethiopian Wildlife and Natural History Society	Kinfe Abebe is Executive Director. Mengistu Wondafrash is Biodiversity Conservation Team Leader and Programmes Director. Described scoping study and Border reservoir's potential impact on Dabus Valley – candidate for IBA. Still candidate because no more data. Will mention in our report, and include need for ornithologist in TOR for full EIA. This will involve at least two surveys – in both migration seasons – Oct to Feb, and end April to early September (back to breed in Europe). 3 No. Bald Ibis are satellite tagged, Syria/Yemen/Ethiopia migration – RSPB coordinated; Mengistu Wondafrash informed of location and found them with GPS. We are advised to see Investment Offices in the two Regions to learn about other ongoing and proposed developments – Region 4 in Asosa and Oromio office in Addis. Mengistu Wondafrash visited RSPB and Birdlife International in UK; knows Thomas and Leon Bennum at BI in Cambridge (both known to ASW). Sudan wetlands contact is Ali Kodi (Wildlife, Gov of Sudan). Ethiopian government dept head WCD is in Min of Ag.
30/10/06	**Ato Kassaye** Ethiopian Mapping Authority	Reported major road mapping error (by about 10 km) on Sheet 1135 C4, found when travelling to Border dam site. Sheets 1135 C3 (with Border dam site) and 1035 A1 are available as orthophoto maps.
30/10/06	**Dr Wolde Bewket** AA University, Geography Department	Regional Atlas of Oromio available from state office. Atlases for Benishangul-Gumuz and Amhara may be under preparation. His interest is in watershed management – thesis on erosion of Chemoga catchment area, 366 km2. Research on climate change by many includes Deklan Conway at Norwich, UK. Predicted Ethiopia's climate change - temperature increases, rainfall intensity increases, more erosivity, but no agreement on changes in quantity of rainfall. Research on Addis rainfall from 1890s – no evident change in quantity. List of publications - 5 papers in 2000s.
30/10/06	**Dr. Abeje Berhanu** AA University, Sociology Department	Involved in consultancy work for ENTRO - synthesising/blending country reports on socio-economic features of the Abay/Nile river basin with no political frontiers. Discussion on linguistic areas mapping.

Consultations during Inception Mission in Ethiopia, 21st to 31st October 2006

Meeting Date	Person/Agency	Environmental issues raised and discussed in Addis Ababa
30/10/06	**Dr. Bayu Chane** AA University Faculty of Technology, Civil Engineering	Discussion on erosion/sedimentation problem. Noted forthcoming December 2006 symposium under NBI series. Dr. Chane is on technical committee. So far, no paper offered on Abbay water management issues. Low agricultural productions cannot sustain farmer's life; incomes decreasing; marginal land being used, even ropes to cultivate inaccessible steep areas. Introduced to work of Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). Challenged to how show benefit to farmer of his efforts to • Reduce sediment loads by his soil conservation works, and • Reduce Carbon emissions by using less fuel wood. Examples of forced displacement of people at small dams in Ethiopia to protect dam catchments – considered OK but population is not happy, and is predicted to return in so many years.
31/10/06	**Ato Kassaye and Degelo Sendabo**, (Head of Remote Sensing) Ethiopian Mapping Authority	Purchased orthophoto maps at 1:50,000 of Sheets 1135 C3 (with Border dam site) and 1035 A1 (further south). Landsat 2000 available, hard copies and CD for whole country. Viewed sample of Landsat TM for 170/052 for Border (already loaded). Image to south is 170/053 - for Mandaya if not on first quoted image scene. Noted preference for Quickbird and Ikonos at cost of USD 29/km^2.

Consultations during Inception Mission in Sudan, 1st to 7th November 2006

Meeting Date	Person/Agency	Environmental issues raised and discussed in Khartoum and Dongola/Dal
1/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources – focal point for study	On arrival in Khartoum from Addis Ababa, advise on ENTRO study inception stage and proposed safari to Dal.
1/11/06	**Yahia Abdel Mageed** YAM Consultants	Khartoum. Discussion on Abbay water resources development scenarios.
3/11/06	**Kamal** Irrigation Department at Dongola	Dongola. Visited river gauging station at Dongola, downstream of ferry on right bank. Kamal then attended two-day visit to Dal and other cataracts. Discussed hydrometric issues relating to other Nile stations, observers, gauging by Egyptian team, etc.
4/11/06	**Residents at Dal**	Dal. Discussions on possible project and resettlement concepts; fish (caught and eaten daily), bird flyway, sand dune encroachment, water supply. A left bank village - no vehicles here. Note. Dal is 278 km from Dongola, and 825 km from Khartoum.
5/11/06	**Commissioner at Dongola**	Dongola. Courtesy call to inform him about ENTRO project and future field studies relating to Dal.
5/11/06	**Elfatih Elajib**, New Hamdab Research Station, Ministry of Science and Technology, Agricultural Research and Technology Corporation	New Hamdab Research Station. Watched promotional video of Merowe project. Discussions on establishment of research centre, crop trials and responses to organic and inorganic fertilizers.
6/11/06	**Tageldin Faragalla Dalil** NEC	Khartoum. Report on 4-day safari to Kajbar and Dal cataracts. Inspected one volume of Russian feasibility report on Kajbar – but no contours. There had been significant protests about resettlement to President by local people; some claim manipulation of local people (to protest).
6/11/06	**Bushra Abdalla Gadalla**, NEC	Khartoum. Description of pre-feasibility studies to Acting General Manager. Emphasis on sediment transport problems.
6/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources	Khartoum. Report on 4-day safari to Kajbar and Dal cataracts. Chasing reports by Coyne/Gibb; Russian Kajbar volumes; and recession agriculture by FAO Africover – National Forest

Consultations during Inception Mission in Sudan, 1st to 7th November 2006		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Khartoum and Dongola/Dal**
		Corporation or Remote Sensing. Discussion of UNESCO work on sand encroachment of Lake Nasser/Nubia – only TORs, not a report.
7/11/06	**Bader El Din Ali Mohamed**, Mierag Space Technologies Company	Khartoum. 1:100,000 mapping unknown of Dongola – Dal - Akasha area. Only available mapping is at 1:250,000. Copy printed from Akasha in north to Dongola in south - many old features recorded on this map (probably dated 1930s).
7/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources	Khartoum. Discussion of 1988 and 2006 floods. 1998 was normal flood from upstream, augmented by local intense runoff along main Nile. No early warning system in place then; much damage. 2006 flood is new historical maximum - this was later disputed – see note below. Thus flooded area and recession agriculture potential at historical maximum this year. What is return period? National Defence early warning system in place; much damage was avoided and assistance was provided. NBI Flood Project now moving to 2nd phase with national flood forecasting centres in Ethiopia and Sudan, and reaching out to communities.
7/11/06	**Dr. Amna Ahmed Hamid**, Remote Sensing Authority	Khartoum. On-screen demonstration of mapping of Africover – project led by National Forest Corporation. Amna participated in the project. Potential for abstracting gross areas (in hectares) of recession agriculture and other Nile water dependent vegetation along main Nile; RSA is now working on year 2000 imagery. There is a postgraduate student, Yasir Moheildeen at University of Surrey, UK, doing something similar – discuss.
	Dr. Asim Ibrahim El Moghraby, Consultant	Khartoum. Considered that the recent Nile flood in 2006 was not the historical maximum – a flood in the 1940s being the greatest, followed by 1988 flood.

Consultations in Addis Ababa 5th to 13th March 2007		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Addis Ababa**
5/03/07	**Tesfaye Batu Bayou** Director, Regional Interconnection Projects Coordination Department; EEPCO	Introduce ENTRO study of three dams and interconnections between three countries.
5/03/07	**Mikias Sissay**, Head, Communication and Information Management Unit, FAO-Ethiopia	Looking for AfriCover mapping for Ethiopia. Not available at FAO, Addis.
7/03/07	**Dawit Tefferra** and **Surafel Mamo**, Hydraulic Engineer, Hydrology Department, MOWR.	Neither have visited Border gauging station. Few calibration gaugings in recent years but they follow the well established and static rating curve of many years ago where $Q=80\ (H+0.28)^{2.02}$ For H <15 m. Hydata used. Single rating used through history. Stage records as follows 24/5/61 to 1980 - more or less continuous. 1980 – 1999 – no records for about 20 years except around 1984 for a year or so 1999 – 2007 - more or less continuous. Maximum recorded level = 12.00 m 18 August 2001, Q = 12,684 cumec Max gauged flow H about 9.8 m and Q about 7,500 cumec. No sediment sampling in last 10 years in Ethiopia therefore conclude sediment measurements have not been made at Border

		since 1980 because there were no flow records from 1980 to 1999. Nothing for 27 years. Now a sign of restarting. Samples to Amichel Laboratory complex.
8/03/07	**Soloman Kebede**, Hydrologist, MOWR, coordinator of regional gauging program	Never visited Border station. Cableway and cable car. Observer lives on left bank. Gauging team stopped – too expensive. Now special crew used. Only low flows measures - fear of cable (USGS cable is over 40 years old) being unserviceable. Sag in cable exhausts operators. No high flow sediment measurements. Electric winch originally, but abandoned. Crocodiles below cable. Cable marked at 2 m intervals. Opportunity for USAID help with refurbishing cablweway and for cooperation with Sudan. Introduction to Famine Early Warning System.
8/03/07	**Kibru Mamush**, USAID	Explore potential for technical assistance concerning rehabilitation of Border gauging station. Discussion on population census 1994. Projections may be on government website.
9/03/07	**Tamene Tiruneh** Environmental adviser. Ethiopia Canada cooperation office (ECCO)	Discussion on ECCO's areas of interest - food security (biggest of CIDA) and government capacity building. Before 2004, supported Benishangul Gumuz and Amhara regions; older projects still running. Food security project in Benishangul, with OXFAM Canada and local consultant with regional government.
12/03/07	**Hayalsew Yilma** Head of Irrigation, MOWR	Discussion on irrigation in Beles catchment area, and feasibility studies of irrigation in Abbay basin by Tahal Consulting Engineers with MWH (Chicago) and Concert Engineering and Consulting Enterprise PLC (Ethiopia); and on Resettlement Policy and Environmental and Social Management Frameworks for Ethiopia Irrigation and Drainage Project by Environmental Resources Management Ltd, Washington.
12/03/07	**Girme Borishie**, Deputy Director, Administration & Finance, and **Ato Oes-Beredu Bekalo**, Mekan Yesus Church HQ, Addis.	Discussion on mission at Boka (where geologist, surveyor and environmental team would be based for boat surveys at Mandaya). Oes-Beredu Bekalo stayed overnight at Boka over 10 years ago.
12/03/07	**Yonas Teklemichael**, EIA specialist, EPA	Discussion on future impacts on Roseires of Beles hydropower project in relation to peaking regime and aggravated sediment transport – no EIA report received. Noted report on Beles – Bahir Dar – Debre Markos – Sululta 400 kV power transmission line project, Environmental and Social Impact assessment, June 2006, for unit costs if needed. Institutional strengthening – need to build up EPA at Asosa – no capacity to monitor. No PCBs in transmission line – persistent pollutants. Legal framework - contextualise text re the project.
12/03/07	**Dr. Paulos Dubale**, former Director of Soil and Water Research Institute, now with Tearfund projects	Noted roles of NGOs in future resettlement projects and that Ato Yare Gal Aysheshu, chief of of Benishangul Gumuz in Asosa, called at office, welcoming church participation in development. Soil erosion Abbay basin – noted research in in Gojam; Dejene pilot scheme 1974 and 1990. Ben Somerveld (Dutch) completed research for PhD, 1998/99; now in World Bank. Tearfund has high intensity area focus, emphasising holistic approach through to food security. Emphasises working through local church - OK for soil conservation measures.
12/03/07	**Dr.Tamirat Bekele**, consulting ecologist for TROPICS	Discussion on draft report, and TORs to include say 2 teams of surveyors working from both ends of reservoir after the rains.
13/03/07	**Girum Kebede**, Ethiopian Sudan project Manager, EEPCO	Discussion on transmission lines and compensation unit costs of SMEC interconnection study, recent Asosa line And Beles-Bahir Dar line.

Consultations in Khartoum 13th to 19th March 2007		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Khartoum**
15/03/07	**Eng. Ibrahim Salih**	Go through simulations of Mandaya. Recession agriculture 50,000 feddan

Consultations in Khartoum 13th to 19th March 2007		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Khartoum**
	Adam, Ministry of Irrigation and Water Resources	d/s Dongola at risk. Blue Nile recession agriculture is small (but area not known). Projects Directorate is at Wad Medani (2 hours drive) - has irrigation costs data.
15/03/07	**Dr. Amna Hamid,** Remote Sensing Authority	Go through simulations of Mandaya with Amna and Ismail Adam M Zain and another member of staff. Demonstrate win-win for energy; sediment transport reduction – better for Roseires, Sennar, Merowe and Aswan; less maintenance of irrigation canals; raising dry season flows in Sudan – more energy from existing schemes, more water for irrigation in dry season; raising dry season water levels - lower pumping head for irrigation (less fuel). Explore assistance with Africover.
15/03/07	**Ismail Adam M Zain,** RSA	Referred to sedimentation of Lake Nubia with formation of island 30 km long by 2.5 to 4 km wide, area 80 km^2 in imagery on 9 November 1972. Flooding of Nubian crops on islands – HAD operations blamed by farmers.
16/03/07	**Dr Asim El Moghraby,** consulting ecologist	Confirmed that there is fish recruitment in floodplain; no plankton in Blue Nile in floods; recession agriculture – see Omdurman flood plain; Sleim and Khoailr basins wetlands grow beans; Dongola area – important if miss flood; loss of fertility; confirms additional pumping costs – pumps and fuel but notes advantage - extension of cropping season by three months when not flooded.
17/03/07	**Eng. Karori El Hag** Ministry of Irrigation and Water Resources	Capital cost of planning, surveying, designing and implementing new pumped irrigation areas is USD 1,000 per feddan. Existing plans for 121,000 feddan to be converted to irrigation. Details of 7 schemes received. For annual recurrent costs of 14 to 16 hours per day pumping, maintenance and fuel, see General Director (mechanical and electrical engineers) at Wad Medani. Two other components would be critically affected by reduced, or no, annual Blue Nile flood. a) All river banks from Roseires to Lake Nubia. These areas provide grazing for livestock, cultivation of horticultural crops, and date palms and citrus. b) Irrigation and domestic water supply areas away from the river supported by groundwater which is recharged by annual flood. These areas are called matras. These Matras areas are greater in area than the river bank areas. Along the Blue Nile, there are wetlands, maya, depressions which shrink without flooding. Roseires has caused this. Impacts on grazing and wildlife. Sediment load is regarded not as pollution but as fertility. Artificial fertilizers would be required. Aswan. 5,000 MCM evaporation losses can be saved at Aswan by operating at a lower level, according to Dr. Salaheldin Yousif in JMP – joint multipurpose projects.
17/03/07	**Eng. Hayder Yousif Bakhiet,** Nile Water Department	Go through Mandaya simulations with Hayder (and General Director called in). Arranged visit to RGS Khartoum.
17/03/07	**Eng. Abdulla Elsadile Elamein,** Nile Water Department	Visited river gauging on Blue Nile in Khartoum. Upper gauges dry, silted channel leading to gauges from river through alluvium. Silt is cleared before arrival of flood season. Zero of gauge is 363 masl (Alexandria datum). Therefore 17 m is equivalent to 380 masl contour. Greatest flood level in history = 17.14 m on 2nd December 1946. At that time, high level gauges were in Palace grounds. They were re-sited here because of security reasons and getting access without security clearance. Flow gauging takes place further upstream. Previously, standard gauging by boat and current meter (0.5 d, for simplicity when gauging, and adjustment factor). Then 0.6d, or 0.2d and 0.8d method used. Gauging took 3 hours. Recently, ADCB method used, taking 30 minutes. But problem in high flows when loaded with silt. El Deim station is located 117 km upstream of Roseires dam, at the border.

<table>
<tr><th colspan="3">Consultations in Khartoum 13th to 19th March 2007</th></tr>
<tr><th>Meeting Date</th><th>Person/Agency</th><th>Environmental issues raised and discussed in Khartoum</th></tr>
<tr><td></td><td></td><td>Roseires reservoir is 80 km long, so RGS is 37 km upstream of reservoir and not in backwater of reservoir during high reservoir levels. The station has a cable and cable car, in disrepair. Security issues also cause problems for gauging.</td></tr>
<tr><td>18/03/07</td><td>Dr Salheldin Yousif, Chairman Water Resources Technical Organ. TAC Member & Eng. Badr Eldin Taha, Ministry of Irrigation and Water Resources</td><td>Former exposure to Addis Ababa transformed his views about cooperation. Sees no significant impact of irrigation in Ethiopia. Ethiopian Minister of Water Resources visited Sudan and understood what serious irrigation is about - a huge arid and hot plain in Sudan, not in Ethiopia. The first document made available to Sudan was Karadobi report - very significant and helpful step. Many cases where knowledge of Abbay flood hydrograph would assist operations at Roseires, especially for closing gates to fill the reservoir.
Erosion in Ethiopia – soil conservation measures to be couched in terms of mobilisation of communities.</td></tr>
<tr><td>18/03/07</td><td>Eng. Ibrahim Salih Adam, Ministry of Irrigation and Water Resources</td><td>Phoned General Directorate (mechanical and electrical engineers) at Wad Medani. Mechanical directorate in charge of pumping and maintenance has formed a committee to assess state's annual expenditure along Blue and Main Nile. In future can provide annual running costs per feddan but not now. Sugar projects should have reports on costs, e.g. Kenana.
Aswan evaporation losses. Scoping study done by Dr Sala's JMP. Max level at Aswan is 183 masl when spills to Toshka valley. Normal operating level is 179 masl. Design losses are 10 BCM/yr. Sometimes 15 BCM/yr.
There is no known comprehensive paper on Nile irrigation.</td></tr>
<tr><td>18/03/07</td><td>Eng. Karori El Hag Ministry of Irrigation and Water Resources</td><td>Confirmed that there is no known comprehensive paper on Nile irrigation. Must get from individual States directly, but no more visits.
Confirmed that 7 No. natural flood basins are planned to be converted to irrigation in the next 10 years. No need for Mandaya or Border mitigation costs to include these.
No data on river bank flooding, or mataras. All are important. Blue Nile backwater on White Nile, Omdurman recession agriculture, not so big.
Mayas between Dinder and Rahad. Roseires has already reduced flooding to Sennar.</td></tr>
<tr><td>18/03/07</td><td>Eng. Hayder Yousif Bakhiet, Nile Water Department</td><td>Collected rating curves for El Deim, Khartoum and Dongola.
<table>
<tr><th>Station</th><th>Level m</th><th>Flow MCM/d</th><th>Flow Cumec</th><th>Rating</th></tr>
<tr><td>Deim</td><td>7.07</td><td>24</td><td>278</td><td>$Q= 6.419 (G-5.3)^{2.34}$</td></tr>
<tr><td>Khartoum</td><td>10.80</td><td>62</td><td>717</td><td>$Q = 20.96 (G-8.8)^{1.57}$</td></tr>
<tr><td>Shendi</td><td>11.16</td><td></td><td></td><td>Not rated, levels only</td></tr>
<tr><td>Dongola</td><td>9.52</td><td>68</td><td>787</td><td>$Q = 7.20 (G-6.7)^{2.17}$</td></tr>
</table>
Collected flood warning control level data for Deim, Khartoum, Shendi, Atbara and Dongola.
FEWS – not operating well so far but Nile Basin Flood Preparedness and Early warning can help a lot. Need for Ethiopia's real time hydrographs for operating Roseires.</td></tr>
<tr><td>18/03/07</td><td>Eng. Yahia A Mageed, YAM Consultants</td><td>YAM installed El Deim gauging station. Neypric gear used. Agrees one station only needed, with two data loggers if required. Flow rating good at both but no comprehensive sediment sampling.</td></tr>
<tr><td>19/03/07</td><td>Eng. Abdulla Elsadile Elamein, Nile Water Department</td><td>El Deim gauging station operated with cableway and cable car from 1965 to about 1980. Big team, with housing, destroyed later. Formerly, 16 staff when required. Driver with vehicle, mechanic for car and cableway, wireless operator, oil man for generator, 4 guards for rest house and cableway.
A tower has slipped; cable sag, making cable car operations too difficult. Needs complete refurbishment, plus accessories. Now 2 staff plus gauge reader. Wireless reporting of level each day. Level readings 3 per day at 6, 12 and 6pm. In July, August and September, in floods, every 2 hours, 24 hours; at night with torch.
117 km 6-hour drive from Roseires dam - most difficult station. Reservoir extent 75 km. Therefore 42 km u/s of backwater. Slope 25 cm per km to Roseires, 15 cm per km downstream of Roseires.
Zero of gauge is 481.20. Max water level at dam is 480 masl. Maximum</td></tr>
</table>

Consultations in Khartoum 13th to 19th March 2007

Meeting Date	Person/Agency	Environmental issues raised and discussed in Khartoum
		flood level at RGS is 13.96 m. therefore 495.16 masl. RGS still OK if Roseires raised. Original rating stable, confirmed by low flow (boat) and float gaugings. Sediment sampling from 1965 to about 1980. 5 verticals, 5 variable depth samples. Total 25 samples for one effort. Liquor decanted. Dissolved Salt (called lime) concentration determined. SS concentration determined. Salt deducted. Sampler lowered on "rope" to required depth, opened, closed. 500 ml samples when bottle full. Results for 25 samples. Since 1980, hand grab samples taken on left and right banks in order "to get some idea, something". Adjustment factor, if one used, unknown by Abdulla. Wad Medani do sediment rating and processing. No high quality sediment sampling for at least 27 years because cable car unusable. December 2006 survey of Roseires dam. Original storage 3.5 milliards, now 2.1. 1.4 lost.
19/03/07	**Eng. Karori El Hag,** Ministry of Irrigation and Water Resources	Six of the seven schemes, 121,000 feddan, proposed for irrigation currently have annual flood for one season giving one crop. The exception is at Letti which has pumping in the dry season; Letti has 2 crops per year. Six schemes to be pumped in dry season in next 10 years, like Letti. With Border or Mandaya, all will need pumping for winter season. Irrigation schemes, pumping both seasons. Less pumping head in good flood season (just delivery head) but extra pumping costs when flood is small and suction head high, and sediment problems. With Border and Mandaya, all will need pumping for winter season, plus the usual summer season. Extra running costs; they double. 1.5 million dependent on the annual flood. Eng. Karori says many more in festive holidays when relatives return from Saudi and elsewhere – they need feeding. Also, many in Khartoum have land there, under Sharia law, and obtain some income from the flood. They are stakeholders too.

Consultations in Cairo 25th March 2007

Eng. Mohammed Nasser Ezzat
Adviser to H.E. Minister of Water Resources and Irrigation. ENSAPT Member. Member of Negotiation Committee for Legal and Institutional Framework. Head of Egyptian Water Resources Association – an NGO.
Irrigation Building, 13 Mourand Street.

Sections in this Ministry building, which is not Ministry HQ, are

- Nile Water Sector
- Forecast
- HAD
- Egyptian Authority
- Centre for Water Research
- Hydraulic Drainage Institute
- Deep Water

400 boats on the Nile. Navigation important.
Rice and cotton in early days, unregulated flows too low, then raised by HAD. Eastern Nile planning and operational model being developed now.
Ethiopian power needed by 2015, according to EDF.
Interconnection with Syria, Jordan, and Morocco, and Europe.
All power generated can be used. It is wanted (provided price competes with alternative sources).

Hydro is so environmentally sound but one problem is security. Not referring to political risk – no sabotage from 3 countries, but referring to cranks. Risk analysis needed.

Consultations in Cairo 25th March 2007

15-17 BCM scheme preferred. Easier to promote. e.g. USBR size, not 49 BCM. ASW referred to need to provide for sedimentation.

Egypt established Authority of Changing Basin Irrigation. Almost 2 million acres irrigated by flooding before HAD. Change to perennial irrigation, prepared canals. 2 crops, some 3 crops. Co-operative Societies formed, provide farmers with services – tractors, fertilizers, all on loans. Pay back after harvest. Financial problems. And silting problems in Sudan.

In Sudan, noted that rainfed agriculture is more economic than irrigated farming.

Rice and wheat – may not be efficient water users. Egypt thinking of importing wheat. But rice needed on edge of delta as a buffer against Mediterranean.

River training is essential when silt reduced. Expect adjustments in morphology. Egypt has a Section for Protection of the Nile in MOWR&I. River will shift with less sediment.

Sediment loads have increased since HAD, especially last 10-15 years. Data available from surveys but not here – at Aswan.

Meeting continued with
Eng. Mohammed Nasser Ezzat and
Eng. Ahmed Fahmy, both former directors in MOWR&I

Merowe dam - no benefit to Egypt so not a joint venture.
Missing data. How to infill? Feasibility studies must say methods used in order to be useful in Egypt.
Agree that well calibrated station at Border or El Deim is essential, with attention to hysteresis looping in flow and sediment rating curves.
Economist should sit here and go through models and costing. How to value a cubic metre at Aswan? But not practicable in this pre-feasibility study.
Mubarak Pumping Station is constructed but unused. No irrigation directly from Lake Nasser. When it occurs, will be taken from allocation with reduction elsewhere. Sudan hydrometrist at Gaafra RGS below Aswan measures the flows. When Mubarak pumps, Sudan engineer will be posted there too.

Toshka spillway at 178 masl is upstream of Mubarak pumping station. Totally separate projects, only name in common.

Resettlement is very costly. Social services costly. Problem in getting farmers at Toshka. New town? No, not yet, only fly camps may be there. Cannot run canal for tiny irrigation; using groundwater.

Evaporation. Must run many data series, not one. Needs inflow data with report. Egypt will be asked to comment. Report to clarify what used. ASW noted pre-feasibility stage, using available data; sub-studies should follow which should justify data used.

Sediment at Karadobi – only 50 years.

Impressive comprehensive book of hydrology data output. Prints of PC data. All Nile hydrology. ASW on need for establishing a full station history of Border gauging station.

First filling studies with conjunctive use of HAD. Assistance needed. Future sub study to involve Egypt because of importance of water demands from HAD.

Appendix 4.1

List of phytoplankton species from samples in Abbay river taken near Abagole and at Mandaya dam site in March 2007

Diatoms (Bacillariophyceae)

Cymbella Sp.
Gomphonema Sp.
Gyrosigma Sp.
Melosira Sp.
Navicula Sp.
Epithemia Sp.
Surirella Sp.
Pinnularia Sp.
Synedra Sp.
Nitzischia Sp.
Amphora ovalis
Diploneis Sp.
Rhizosolenia longiseta

Blue Green algae (Cyanophyceae)

Anabaenopsis Sp
Lyngbya
Anabaena

Green algae (Chlorophyceae)

- *Staurastrum* Sp.
- *Cosmarium* Sp.
- *Pediastrum* Sp.
- *Scenedesmus* Sp.
- *Comphosphaeria aponina*
- *Treubaria* Sp.
- *Closterium*

Appendix 4.2

List of phytoplankton species from samples in Abbay river at Bure-Nekempte bridge in January 2007

Diatoms
Nitzschia sp.
Navicula sp.
Volvocales sp.
Gyrosigma sp.
Frustulia sp.

Blue green algae
Lyngbya sp.

Green algae
Cosmarium sp.

Chryptophyta
Cryptomonad sp.

Appendix 4.3

List of fish species collected from Abbay river on 21 and 22 March 2007 at Abagole, downstream of Mandaya dam site

Family	Species
Cyprinidae	*Labeo cylindricus*
	Labeo forskalii
	Labeobarbus sp.
	Raiamas laoti
Bagridae	*Bagrus docmak*
	Bagrus bajad
Claridae	*Clarias gariepinus*
Cichlidae	*Oreochromis niloticus*
Mormyridae	*Mormyrus kannume*
Alestidae	*Hydrocynus forskalii*

Appendix 4.4

Fishes of the Abbay river at Bure-Nekempte bridge (NFLARR/EARO, 2003) (Date of sampling 20-24/03/1992)

Family	Species
Mormyridae	*Hyperopisus bebe*
	Mormyrops sp.
	Mormyrus haaelquistii
	Mormyrus sp.
Characidae	*Micralestes sp.*
Cyprinidae	*Barbus intermedius*
	Barbus sp.
	Chelaethiops bibie
	Garra sp. With red spot
	Labeo cubie
	Labeo sp.
	Leptocypris sp.
Bagridae	*Bagrus sp*.
Schilbeidae	*Schilbe sp*.
Mochokidae	*Synodontis sp*.

Appendix 4.5

Fishes of the Beles River at Babizenda
(Source: Zeleke Berie, 2007)

Family	Species name	Common Name
Cyprinidae	*Labeo coubie*	Tsemebebella
	Labeo cylindricus	Tseya
	Labeo horie	Tsemebebella
	Labeo forskalii	Tseya
	Labeo niloticus	Tsemebebella
	Labeobarbus bynni	*Goshe*
	Labeobarbus intermedius	*Goshe*
	Labeobarbus nedgia	*Goshe*
	Labeobarbus degeni	*Goshe*
	Raiamas loati	*Abella*
	Varicorhinus beso	*Abella*
Bagridae	*Bagrus bajad*	
	Bagrus docmak	
Claridae	*Clarias gariepinus*	
	Heterobranchus longifilis	
	Auchenoglanis occidentalis	*Jajuma*
Mochokidae	*Synodontis serratus*	
	Synodontis schall	*Buwa*
Characidae	*Hydrocynus forskalii*	
	Brycinus macrolepidotus	*Yechacheya*
	Brycinus nurse	*Lekewar*
Mormyridae	*Mormyrus kannume*	*Bebela*
Cichlidae	*Oreochromis niloticus*	*Begebella*

Appendix 4.6

Fishes of the Abbay River at a location 35 km SWW Mankush (11°14'N 34°59'E) (Source-JERBE, 2000)

Mormyrops anguilloides (Linnaeus, 1758)

Mormyrus cashive (Linnaeus, 1758)

M.hasselquistii (Valenciennes, 1846)

M.kannume (Forskal, 1775)

Pollimyrus petherici (Boulenger, 1898)

Alestes sp**.**

Brycinus macrolepidotus (Valenciennes, 1852)

B.nurse (Ruppell, 1832)

Hydrocynus forskalii (Cuvier, 1819)

Micralestes acutidens (Peters, 1852)

Nannocharax sp.

Garra sp.

Leptocypris niloticus (de Joannis, 1835)

Labeo cubie (Ruppell, 1832)

L. cylindricus (Peters, 1852)

L.niloticus (Forsskal, 1775)

B.docmak (Forsskal, 1775)

Schilbe mystus (Linnaeus, 1758)

S. uranoscopus (Ruppell, 1832)

Synodontis frontosus (Vaillant, 1859)

S.schal (Bolch & Schneider, 1801)

S. serratus (Ruppell, 1829)

S. sorex (Gunther, 1864)

Oreochromis niloticus (Linnaeus, 1758)

Appendix 4.7

Fishes of the Dabus River at the bridge along Nekempt-Assosa road (9° 46' N 34° 48'30''E) (Source: NFLARR/EARO, 2003)

Labeo forskalii (Ruppell, 1835)

Clarias gariepinus (Burchell, 1822)

Oreochromis niloticus (Linnaeus, 1758)

Barbus intermedius (Ruppell, 1836)

B. paludinosus (Peters, 1852)

Garra sp.

Varicorhinus beso (Ruppell, 1836)

Appendix 4.8

Summary of Boat-assisted fieldwork at Mandaya, 15th – 26th March 2007

Day and Date in March 2007	Locations and personnel	Summary of activities and observations
Thursday 15th	Addis Ababa, Ambo, Nekempti, Gimbi. Jack McFadzean Zelealem Abebe 2 drivers.	0730 departure from Addis Ababa in two Toyota Land Cruisers. All packing and loading of the boat accomplished previous night 1600 at Nekempti. Fuel for the boat (125 litres) and vehicles. Bad roads. Diversions. 110 km from Nekempti to Gimbi takes 3.5 hours. Night at Adventist Hospital guesthouse in Gimbi town.
Friday 16th	Gimbi Mendi Koncho (Sirba Abbay) Boka village. Jack McFadzean Zelealem Abebe Geleta Sediko 2 drivers.	0700 departure, arrive Boka at 1630. Road from Gimbi to Mendi under construction (typical average speed, 20-30 km/h). Significant erosion in cuts along the new asphalt road, potentially increasing sediment loads in tributaries of Abbay. Contacted the Koncho woreda administration; met woreda vice-administrator who was already acquainted with the project study; the woreda administration assigned Mr Geleta Sediko (with shot gun) full time to accompany the study team. Mr Fekadu provided a house with three bedrooms, kitchen, etc. Main house made of wood/mud walls with roof of corrugated iron sheet and grass. House badly affected by termites. Some preferred the tents outside. After unloading, managed to “drive” 2 km to Abbay left bank. This was a bonus, avoiding need to carry boat, heavy boat engine, fuel and equipment – as had been previously expected.
Saturday 17th	Boka village to Mandaya dam site. Returned to Boka. Boat used 35 litres fuel, more than expected. Jack McFadzean Zelealem Abebe Geleta Sediko 2 drivers 2 locals	0700 depart for Abbay river. Bank very steep, water 5 - 6m below top of bank. 0730 to 1230, boat assembled and launched, then outboard engine fitted. Large crocodile observed in mid river. Engine started on first pull. Reconnaissance made to Mandaya dam site; much better flow and rapids conditions than thought in office. 7 persons on board. Engine at half throttle, running in, achieving 16 km/h. First rapids sighted after 20 minutes, large rocks breaking the surface. Hit the bed/rocks a few times; just enough power to creep forward; slow progress. Then rapid progress to halfway to dam centre line (C/L). (Crocodiles are numerous and ubiquitous. Local people say large crocodiles are after goats with no harm to adults or children). At about mid way to the dam site there is an island and people wading across the Abbay; problems expected for boat but narrow, fast flowing 1 km long channel found on the left (right bank side) permitting good passage. Then followed a rocky section, then an island with a passage like the first one, then worst section of all,

Day and Date in March 2007	Locations and personnel	Summary of activities and observations
Saturday 17th (continued)		causing some redesign of the propeller. Altogether, 6 rapids were run, two of these having to be taken slowly. Dam CL reached in about 3 hours on this first journey. Three typical hippos areas noted (about 7 km and 4 km downstream from the dam C/L and at the dam site). Those at the dam site remained *in situ*; others moved. Some panicked, jumping out of the water like dolphins. All in the boat remained fearful. A number of villages were observed on both banks of the river between Boka and the dam site. C/L identified using GPS and coordinates provided by Terry Page (geologist) from earlier visit on foot. Evident that survey of cross section would be difficult. 3 No. noisy hippos were 15 m upstream of C/L and would not move. Departed Mandaya C/L at 1540, arrived at Boka launch site at 1710. Easier passage going downstream. Air temperature 39^{o} C.
Sunday 18th	Boka to Mandaya dam site. Fly camp at Aba Goli village. Jack McFadzean Zelealem Abebe Geleta Sediko Gemechu Wodajo Flow of Blue Nile at Sudan's Deim gauging station at the Ethiopian border reported from Khartoum today Sunday 18th March GH = 0.70m Q = 278 m^3/s	Decided to take tents and establish fly camp near Mandaya. Telephoned environmentalists, setting out from Addis today, requesting 100 litres fuel for boat. Two drivers refuse to come in boat again, fearing rapids, hippo and crocs. Guard with gun finally persuaded to come, plus Gemechu Wodajo, a local Gumuz man as Assistant. 4 No. in boat. Reach dam C/L in two hours. Dam axis survey, the riverine woodland cover hinders open observation and survey. Two climb right bank to plateau, getting lost. The plateau is vast and flat; hexagonal shaped boulders have 25-35 cm diameters; woodland and grass cover. The temperature is 47^{o} C - intolerable. Everyone exhausted. Hippos trail used to investigate the environmental condition in and around the dam site. Attacked antelope observed, probably leopard kill. There are also some illegal hunting practices. Stayed the night some 7 km downstream of the dam site in Aba Goli village, passing through two difficult rapids. Eat fish.

Day and Date in March 2007	Locations and personnel	Summary of activities and observations
Monday 19th	Aba Goli village to Mandaya. Return to Boka launch site. Jack McFadzean Zelealem Abebe Geleta Sediko Gemechu Wodajo	Return to dam site via two rapids. Two climb right bank to plateau assisting survey. Then surveyed island and left TBM for future monitoring of water level changes. Then established peg on right bank (but not on C/L because RB C/L is inaccessible). From this peg, the left bank is surveyed to the top of plateau. Very hot day, no shade, 43^{o} C at 1500. Travel back to Boka launch site in 1.5 hours.
Tuesday 20th	Boka Mekaneyesus Clinic Koncho Boka	No use of boat today. Propeller changed and plugs and gearbox checked. Visit Koncho woreda. Discussions with Agriculture and Rural Development office (Mossisa Meshesha (office head), Alemayehu Geleta (Rural Road Development Desk), Miss Ababa Beyadiglegn (Forest Development Expert). Purchase of some food items and water in Mendi. Discussion with staff in the clinic on major health problems, coverage and problems. Clinic provides service to surrounding people that include Koncho and people from Wonbera woreda across Abbay river. Clinic was established by the church in 1995. Lack of refrigerator affects treatment of typhus, typhoid and other cases. Children and women are the major beneficiaries of the clinic. The temperature in the clinic room temperature 40^{o}C; outside temperature 46 and 50^{o}C. Dr Abebe Getahun, Dr Tamirat Bekele, Mr Abraham (Geologist) arrive in evening. Also, Sister Hilde, Norwegian nursing teacher.
Wednesday 21st	Boka Mandaya Boka Jack McFadzean Zelealem Abebe Abebe Getahun Tamirat Bekele Abraham Two local men Geleta Sediko Gemechu Wodajo	Boat to Mandaya dam site; 7 persons on board plus much equipment; overloaded; some passengers disembark temporarily to walk past rapids. Local fishermen noted using gill and beach nets. Abebe Getahun disembarks at first island for fish and plankton sampling. Abraham (geologist) disembarks 5 km downstream of C/L for survey. Now boat can plane. Terrestrial ecology survey; collection of specimens of riverine and other vegetation. River cross section survey with rope; very difficult and hard work because of strong current, hippos and temperature, 39^{o}C; river bed of rock and gravel. Return downstream, picking up surveyors. All exhausted. Discussion with Sister Hilde Massvie. She mentions prior discussion with Benshangul Regional State about conforming with settlement planning and establishment of clinic and other development activities by the church. But settlement is proceeding outside the planned area.

Day and Date in March 2007	Locations and personnel	Summary of activities and observations
Thursday 22nd	Boka, upstream of Mandaya C/L into reservoir area Boka Jack McFadzean Abebe Getahun Tamirat Bekele Abraham One local assistant	5 persons on board. Local fishermen noted using gill and beach nets. Fish nets left with local people at 10 km so they may collect samples. Continued to dam site C/L for geological survey to continue on right bank. Proceed for first time upstream of Mandaya C/L, passing two rapids for more aquatic and ecological surveys and collection of specimens. At 10 km upstream of C/L, rapids impassable, river too shallow to proceed further to Didessa confluence. Turn around. Once out of gorge, see many people again on both banks. One group is panning for gold. More hippos. Pick up nets and big catch of fish. 45 litres of fuel remaining. Eat fish. Mattress alive with bed bugs.
Friday 23rd	Boka, Mandaya dam site, Boka	Abebe Getahun and Tamirat Bekele depart, returning to Addis Conduct remaining geological investigation upstream and downstream of C/L. 5 litres of fuel remaining. Loading of the boat and equipment.
Saturday 24th	Boka Koncho Mendi Nekempti	0800 depart. 0900 pass Koncho. 1015 pass Mendi. 1900 arrive at Nekempti. All hotels full. Go out of town. No food today.
Sunday 25th	Nekempti Addis Ababa	0700 depart. 1630 arrive in Addis. Unload boat and equipment at Scott Wilson house.

Survey Participants (10 No.)	Responsibility
Jack McFadzean	Surveyor and boat operator
Zelalem Abebe	Environmentalist
Dr Tamirat Bekele	Terrestrial ecologist
Dr Abebe Getahun	Aquatic ecologist
Abraham	Geologist
Solomon	Driver
Efrem	Driver
Teshome Abebe	Driver
Geleta Sediko	Local
Gemechu Wodajo	Local

Draft accounts prepared by Zelalem Abebe and Jack McFadzean.

Appendix 4.9

List of contacted people and organizations

No	Name of contacted people	Organization and responsibility	Address
1	H.E Yaregal Ayshishum Benshangul	Benshangul National Regional State BNRS; the region President	
2	Ato Nigusee Abdissa	BNRS GIS section in BoFED	0577751292
3	Ato Ahimed Seid,	BNRS A/Head of the Environmental Protection Land Administration and Use Authority	
4	Ato Yilma Muluken	BNRS A/Head Disaster Prevention and Food Security office	
5	Ato Zekarias Wondeme	BNRS Disaster Prevention and Food Security office, Population and settlement expert	
6	Ato Abdul Mohammod	BNRS A/head BoARD	0911790894
7	Ato Gurmesa Gerbi,	BNRS Agronomy expert BoARD	0911918266
8	Ato Brehanu Hailu	BNRS General Manager BRRDA	0577750326
9	Ato Yehun Gudeta	BNRS Man power Administration BRRDA	0577750326
10	Ato Sibiel Albened	BNRS Head of Health Bureau	
11	Ato Mohammod Musa	BNRS Plan and Program expert BoH	
12	Ato Sherif Abdelahi	BNRS A/Head Education	0577750068
13	Ato Muhedine	BNRS BoE Plan and program expert	0577750068
14	Ato Mogose Debebew	BNRS Study and Design Department head BoWMED	0577750719
15	Ato Minilike Wubie	BNRS Head BoWMED	
16	Ato Seyfedin Omer	BNRS Administrator Sherkole woreda	
17	Ato Hamad Ahimed	BNRS Sherkole Woreda Speaker of the House	
18	Ato. Haile Babur	BNRS Vice Administrator Sirba Abbay	
19	Ato Kelifa Lefa	ONRS Acting Head East Wolega Administration office	0576611080

No	Name of contacted people	Organization and responsibility	Address
20	Ato Jegi Kitessa	ONRS Head Agriculture and Rural Development Office, Oromia Regional State	0576614748
21	Ato Getenet Temesgen	ONRS Head Oromia Irrigation Authority	0576613385
22	Ato Tadesse Soni	ONRS Construction and Supervision Department Head, Oromia Irrigation Authority	0576613385
23	Ato Bekele Ararssa	ONRS Study and Design Head, Oromia Irrigation Authority	0576613385
24		BNRS Yasso Woreda Administration Head	
25	H.E Ato Demeke Mekonnen	ANRS Vice Regional State President	
26	Ato Brehanu Ayechew	ANRS The Presidents Advisor	0582200231
27	Ato Mamar	ANRS Water Mines and Energy Development, Head	
28	Ato Alemayehu Tekele	ANRS WoWEMD Irrigation Development Study & Design Head	
29	Ato Mulualem	ANRS BoWEMD Irrigation Operation and Maintenance Head	
30	AtoYessema Damena Head of Contract Administration BoWEMD	ANRS BoWEMD Contract Administration Head	
31	Ato Girma Tesfay	ANRS BoFED, Vice	
32	Ato Alemnew Allelegn	ANRS BoARD Acting Head	
33	Ato Ayene mulu	ANRS BoARD Statistics	0582202995
34	Ato Girma	ANRS BoFED	
35	AtoDerege Seyume	Manager of ANRS Investment Promotion Agency	
36	Ato Mohammod Abdurazake	BNRS Guba Woreda Administration Security and Justice	0981190057
37	Ato Fanta Achameyelhe	BNRS Yarenja Refugee Camp, Director	
38	Ato Teshome Nassine	BNRS Yarenja Refugee Camp Police	
39	Ato Awede Algemer	BNRS Guba Woreda Administration Head	0981190057

No	Name of contacted people	Organization and responsibility	Address
40	Dr Babikan	ENTRO, Environmentalist	
41	Ato Yonnas G/Micalel	EPA, Senior Environmentalist	0116464878
42	Ato Geremew G/Selases	EPA, Public Awareness	0116464878
43	W/O Tayech Worgicho	EPA, Public Awareness	0116464878
44	Ato Kinfe Abebe	EWNHS Executive Director	
45	Ato Mengistu Wondafrash	EWNHS Bird specialist, year Director	

Appendix 4.10

Participants of Focus Group Discussion (FGD) at different localities in the project area

Focus Group Discussion I: at Yasso, Yasso woreda capital

No	Name of the Participants	Occupation	Administrative location
1	Ato Dilgassa Sinarra	Farmer	Yasso
2	,, Jeldisu Yohannes	,,	,,
3	,, Aleka Genthsis	,,	,,
4	,, Nigussu Duressa	,,	,,
5	,, Legesse mekonnen	Militia	,,
6	,, Habitamu Gemeda	Public Relation Advisor	,,
7	,, Tesfaye Nenu	Inspector	,,
8	,, Shewngizaw wosson	Woreda HIV office	,,
9	,, Tesfaye Abadi	Student	,,
10	,, Assmamaw Bizualem	Woreda Capacity Build	,,
11	,, Nusha Gusacha	Woreda Administration	,,
12	,, Salbana Tudose	Farmer	,,
13	,, Bagidu Wasu	,,	,,
14	,, Golotu Toshome	,,	,,
15	,, Wokoguri Toldoso	Woreda Capacity Build	,,
16	,, Gozaw Tolla	Rural Development Office	,,
17	,, Jonse Edisa	Woreda Cooperative Office	,,

Focus Group Discussion II: at Harmulu, capital of Sherkole woreda

No	Name of the Participants	Occupation	Administrative location
1	Ato Hussen Yemmam	Woreda Water Desk Acting	Sherkole woreda
2	,, Tibebu Mekonnen	DPPD Expert	,,
3	,, Amare Hojele	Local Residence	,,
4	,, Hassen ahimed	Woreda Justice Office Head	,,
5	,, Seyfedine Oumer	Woreda Administration Head	,,
6	,, Eibasse Fedlemuna	Local Residence	,,
7	,, Fethi Abdurahim	Woreda Administration	,,
8	,, Hassen Mussa	Public Relation	,,
9		Regional ARDB Head	Assossa
10		Regional ARDB, Expert	,,

Focus Group Discussion III: at Koncho, Sirba Abbay woreda capital

No	Name of the Participants	Occupation	Administrative location
1	Ato Mossisa Meshsha	Woreda ARD, Vice	Knocho, Sirba Abbay
2	,, Antenhi shawi	Woreda Administration Head	,, ,,
3	,, Mammach Kena	Cooperative & Public Relation	,, ,,
4	,, Haile Babur	Woreda Administration	,, ,,
5	,, Assmamawe Zegedi	Woreda Administration	,, ,,
6	,, Kassign Fanso	Farmer	,, ,,
7	,, Nagi Mekina	,,	,, ,,
8	,, Milkessa Fekade	,,	,, ,,
9	,, Bekomo Abigussa	,,	,, ,,
10	,, Abede Gussa	,,	,, ,,

Focus Group Discussion IV: at Mankushi, Guba woreda capital

No	Name of the Participants	Occupation	Administrative location
1	Ato Yadeta Barja	Woreda Administration Head	Mankushi, Guba
2	,, Mohammod Abdrazak	Woreda Administration	,,
3	,, Hassen Hamdan	Woreda Capacity Building	,,
4	,, Abud Mussa	Woreda Militia	,,
5	,, Alhire Mohammodnur	Woreda Administration Vice	,,
6	,, Abud Alfal	Woreda Public Relation	,,
7	,, Mohammod Hajerguba	Woreda ARD Office Head	,,
8	,, Ataibe Oussman	Woreda Health Office Head	,,
9	W/o Nura Sali	Woreda FED Office	,,
10	,, Adissu Haile	Police	,,
11	,, Gerbay Wetsei	kebele Chairman	Basheta Kebele

Focus Group Discussion V: at Bercha small village in the DIZ

No	Name of the Participants	Occupation	Administrative location
1	Hajeje banwase	farmer	Bercha kebele
2	Dagnew Abdie	,,	,, ,,
3	Beshur Musa	,,	,, ,,
4	Shaba Habase	,,	,, ,,
5	Lemam Dejaze	,,	,, ,,
6	Chikaweya Osma	,,	,, ,,
7	Gemer Mohommod	,,	,, ,,
8	Rejeb Hanguge	,,	,, ,,
9	Keyetu Rugu	,,	,, ,,
10	Sheref Yonase	,,	,, ,,

Focus Group Discussion VI: at Gomer small village in the DIZ

No	Name of the Participants	Occupation	Administrative location
1	Dabish Shaban	Farmer	Funguso kebele
2	Siddied edriese	,,	,, ,,
3	Borne Besheir	,,	,, ,,
4	Jabat Beshire	,,	,, ,,
5	Attuoo Boko	,,	,, ,,
6	Nofgo Obbo	,,	,, ,,
7	Anbete Fedine	,,	,, ,,
8	Suliman Bedwie	,,	,, ,,
9	Ali beshire	,,	,, ,,
10	Mohammod Bohoray	,,	,, ,,
11	Besheri Sherfedine	,,	,, ,,
12	Merzu Bechu	,,	,, ,,
13	Taliani Jadia	,,	,, ,,
14	Mohommod Gunzea	,,	,, ,,
15	Hoyele Obrasse	,,	,, ,,
16	Babicheri Shayove	,,	,, ,,
17	Mohommed Ali	,,	,, ,,
18	Esmiel Babicher	,,	,, ,,
19	Dawide Abdela	,,	,, ,,
20	Adem defalahe	,,	,, ,,
21	Moris Abderahim	,,	,, ,,
22	Semene Shavan	,,	,, ,,
23	Jebriel edrise	,,	,, ,,
24	Jegna Anghu	,,	,, ,,
25	Gashaw Olmas	,,	,, ,,

No	Name of the Participants	Occupation	Administrative location
26	Hamis Hantum	,,	,, ,,
27	Esa Mohommod	,,	,, ,,
28	Habase Abdela	,,	,, ,,
29	Hamusa Lemie	,,	,, ,,
30	Derge Feleki	,,	,, ,,
31	Mohommed Ofkiea	,,	,, ,,
32	Yosufe Abde	,,	,, ,,

Focus Group Discussion VII: Yabetal small village in the DIZ

No	Name of the Participants	Occupation	Administrative location
1	Nade abdela	Farmer	Yabetal Kebele
2	Yadate Shu	,,	,, ,,
3	Mohommed Esmiel	,,	,, ,,
4	Abshenab babure	,,	,, ,,
5	Ajet Balayee	,,	,, ,,
6	Shanbel tayebe	,,	,, ,,
7	Simet Sannun	,,	,, ,,
8	Tach Shu	,,	,, ,,
9	Absenger Alkuranii	,,	,, ,,
10	Hamisse Hasen	,,	,, ,,
11	Ebrahim Mesad	,,	,, ,,
12	Rejeb Habsewer	,,	,, ,,
13	Hsman Abdela	,,	,, ,,
14	Selasi Musa	,,	,, ,,
15	Ebrahim Teha	,,	,, ,,

No	Name of the Participants	Occupation	Administrative location
16	Sanun Marid	,,	,, ,,
17	Hesen Habshik	,,	,, ,,
18	Bahol Hizabe	,,	,, ,,
19	Semire Osman	,,	,, ,,
20	Sahnun Jebertete	,,	,, ,,
21	Abdelgadier danobshar	,,	,, ,,
22	Bala Musa	,,	,, ,,
23	Hissen Oosman	,,	,, ,,
24	Ablo Abede	,,	,, ,,
25	Kasahun Alkurni	,,	,, ,,
26	Abderhaman Shu	,,	,, ,,

Appendix 4.11

A Nurse's View

Because of the existence of a mission clinic at Boka, located on the left bank of Abbay between the upper end of Border reservoir and Mandaya dam site, the views of a nurse on proposed hydropower developments were sought. This occurred by email communication following geological and ecological surveys based at Boka village in April 2007. The nurse, contacted in Norway, had been living among the Gumuz people from November 2001 until August 2005. She had learned the Gumuz language and had had contact with many people from different villages. She contributed as a nurse, and as one of the public health advisors in the integrated rural development project among the Gumuz, which was operational from 1996 to 2006, through the Norwegian Missionary Society and Mekane Yesus Church. The first two years were spent in Agalo Meti, a neighbour woreda to Sirba Abay woreda, and the next two years at Boka in Sirba Abay.

The nurse's thoughts about the hydropower projects on the Abbay river are direct and sincere. She began by providing some general background and observations, which generally support the socio-economic, cultural and health situations described in Chapter 4.

"When I stayed in the Abbay valley, the government ordered people to move to the centres. (This refers to the resettlement centres referred to in Chapter 4). This would ease the government's possibilities to give school and health station opportunities to everyone. Today (as in 2005) the health stations are not enough, with quite long distances between them and not having enough trained staff or enough support of medicines and materials needed to do their job. The school situation is much better since the government has been concerned to build schools "everywhere" and send trained teachers all over. (This is the history after the downfall of the Derge ~1991/92). This made us think about the consequences when people are to move and nothing is arranged beforehand. The promises were: You move, then we will build and arrange (school, health stations, water points). A few families, but not whole villages, moved at that time.

Larger groups have another health situation, changing the power in the clans, keeping farmers away from their fields.

Ethiopia is experiencing great changes and development, for good and not so good these days. Hopefully, the total outcome in the future will be good for the people although everything is not at its best today. Also, the Gumuz people have to change parts of their way of living and their culture due to this development and governmental laws.

Traditionally, the Gumuz were gatherers and hunters. Today, most of them are farmers, farming their own fields and having some animals. Their money is in their grain (sorghum, maize, and sesame), goats, sheep, chickens, etc. A few have cattle. They live together in clans and their traditions are strongly connected to the fellowship in their families and clans (responsibility to each other, who takes care of who, who can marry, etc)".

The nurse raised seven points of concern, as follows:

(1) Food situation (enough fields and enough people to farm the fields) must be secured.

"When people are resettled/moved to centres, they will lose their close living to their fields. The follow-up of the fields will be less because the distance is too far; more harvest will be taken/destroyed by baboons or monkeys (this is already a problem, why people in periods live at their fields). Also neighbour's animals sometimes enter fields and eat.

The amount of jobs will not be more for farmers than it is today (many above 30 can only do simple reading and mathematics – their life is as farmers). For a few, new opportunities concerning jobs will develop.

Fewer follow-ups of fields (i.e. attention to crop husbandry and crop protection) may cause the amount of grain to be less. This means: even with money you can't buy enough food. Ethiopia is already lacking food for her people".

(2) A clean and sufficient water supply is needed for all throughout the year

"Some places have clean water points. Many of these water points are drying partially or totally in the two last months (April, May) before the rainy season begins in June. Of course, this is influenced by last year's rainfall. How can they support an even larger number of people? Local government workers would solve this by saying: "No problem, the women can collect their water from … (name of local river)" not thinking or caring that it takes around one or two hours to walk each way to that river. This can be particularly difficult and ironic when people were required to move away from the river to the new resettlement centre in the first place. Drilling boreholes and digging wells for water, and making enough water points, can of course solve this".

(3) Prostitution

"You said that for several years around 2,000 workers would be in the valley for construction work. I understand that many workers will have to be brought in from other areas. This will cause prostitution. What are your plans to prevent this?

Prostitution brings HIV/AIDS and other sexually transmitted diseases to the local community. Babies will be born without fathers. Will they become outcasts? What will happen to the prostitutes themselves? Will they be outcasts as well? There is money in prostitution. Don't close your eyes to this problem.

(Two examples were cited, one relating to prostitutes at a road construction workers camp outside a village, the other to a marble company's camp just outside of a village). Both these camps are small, but the problem is there. As far as I know, nothing was done to keep the women/girls away".

(4) Malaria

"Already the area is endemic with malaria. How will such a dam influence the malaria situation, the reservoir being a large breeding place for mosquitoes?"

(5) Culture and assimilation of other people

"The Gumuz people are a strong people. They have been withstanding slavery from other people by moving on instead of letting others get hold of them. But they can't move on now. The children are joining school, there is not space to move on as it was before and a dam will make this space even less. Education, common laws with other Ethiopian people, woredas, trading, etc - the Gumuz are already more influenced by other people than before. This is a part of development, I know, and it will happen one day anyway. But with such a project the changes are made much faster and with less chance to be absorbed and accepted and changed in a way that the people may want. Maybe their strength will continue and they'll manage, maybe they will lose all their self-understanding and give up their life and culture as Gumuz and just live. I am sorry that I can't fully explain myself about this. It is not exactly my field, and I hope I'm being unnecessarily pessimistic at this point.

What will be done by the project to take care of the Gumuz culture in particular? For example, what will happen to their traditions, their way of thinking and living (I'm not talking about their houses or pots) and what is worth taking care of?

When people are resettled, the social security they have today will change. I can't foresee the consequences, but I guess somebody can give ideas about it. They already see changes after governmental laws have been implemented, both positive and negative.

To foresee the consequences of this project; roads into the area, resettlement, construction work force in the building period, the time 10 – 20 years from now; it is not possible to guess these at all".

(6) Education of local people for dam construction employment and for later

"If this project is still a few years ahead, how many people could be sent to school and trained beforehand from the local people? The promise will be to give them a job in the project period, not for the rest of their life. This may be important both to keep the local people positive to the project, and to let them get some of the income. It will also give the local people a better influence over their own future".

(7) Where will the people move?

"Will they be moved to other areas where Gumuz are living or will they be given land in areas where other people are living (e.g. Berta and Oromo people)? To whom does the land belong? Who is in a position to give and take land? Conflicts about land must be avoided".

The nurse has lived closely with Gumuz people and knows much about their health, nutrition and culture. In addition, unlike most local people, she has wide experience and vision of major projects. The seven concerns raised are precisely those met on many other hydropower projects in the past. With well researched social and cultural issues, and the strong will which exists within ENTRO, federal and regional governments, financiers and others for constructing, implementing and monitoring a well conceived resettlement action plan, adoption of World Bank safeguard policies, and further supported by institutional strengthening, there should be every reason to believe that all of these concerns can be suitably and comprehensively addressed – though there will unfortunately always be some shortcomings in practice. Some of the measures are outlined later under impacts and mitigation measures. At feasibility level, they will need to be fully addressed.

Appendix 5.1

Agricultural and settlement land use areas immediately adjacent to the Nile which are dependent on Nile flood water, and Nile river water surface areas

Background

After aerial and site visits to Border and Mandaya dam sites in Ethiopia in October 2006, the Consultant made an inception phase visit to Khartoum in November and visited most agricultural areas along the northern Main Nile from Dongola to Dal in the same month, including visits to Bayuda, Argo, Kerma, Habarab, Fareig, Kagbar, Kadein, Delgo, Abu Sari, Wawa, and Abri. During this visit, consultations were held with irrigation and river gauging station staff at Dongola and with local people. It became very clear that upstream storage developments in Ethiopia might cause significant changes to the Nile's flow regime and to the livelihoods dependent on it in Nile and Northern States.

When RAPSO simulation modelling results of the Border and Mandaya projects became available in December 2006 and January 2007, these concerns were reinforced. They were reported to stakeholders at the ENTRO workshop in Cairo in March 2007.

In order to establish a first approximation of the area which is supported by annual flooding of the Blue Nile and Main Nile for the pre-feasibility studies of Border and Mandaya hydropower projects in Ethiopia for ENTRO in 2007, an analysis of Landsat imagery has been undertaken by the Remote Sensing Authority in Khartoum. The methodology and results are presented below.

The work of the Remote Sensing Authority followed a request in March 2007 from Ministry of Irrigation and Water Resources to Forest Department for an analysis of AfriCover land use data. Ministry of Irrigation and Water Resources made the request because the Ministry is the focal point for ENTRO studies in Khartoum. The request was made to Forestry Department because Forestry Department is the lead agency for developing and administering AfriCover for Sudan in the FAO project.

The request explained that ENTRO has a series of studies relating to understanding how best to share and develop Nile water resources for the equitable benefits of riparian states. One of these studies, concerning power trading, had demonstrated that hydropower projects on the Abbay river in Ethiopia would cause significant changes in Blue Nile and Main Nile discharges and sediment transport in Sudan. Storage and regulation releases in Ethiopia would bring both benefits and adverse impacts to Sudan.

In the event, the AfriCover database was not used and the Remote Sensing Authority carried out this work using more recent satellite images (2001) than used for Sudan in the establishment of the AfriCover database. The Remote Sensing Authority was at the time carrying out a nation-wide assessment of agriculture (rainfed and irrigated) and brought the analysis of the Blue Nile and Main Nile riverine strips forward, to assist this study.

Objectives

The objectives were to quantify the vegetated areas along the Blue and Main Nile which are directly supported by annual river flooding and associated groundwater recharge in the river valley alluvium – a first assessment of vegetated areas supported by river flooding. It was understood that the results would not be perfect but should assist comprehension of the overall magnitude of the river's influence.

Couched In practical terms of the Border and Mandaya projects, the objectives were to provide an order of magnitude assessment of the area which might require pumped water supplies if river regulation reduced or removed most of the Blue Nile's annual flood, and to go on to assess the capital and annual recurrent mitigation costs of converting agricultural areas based on flood recession agriculture to a pumped and canal fed water regime, as has occurred in the Nile valley in Egypt since High Aswan Dam became operational.

Methodology

Agricultural areas adjacent to the Blue and Main Nile, settlement areas adjacent to these agricultural areas and water surface areas of the rivers were abstracted from Landsat Thematic Mapper (TM) dry season images dated November-December 2001. An approach of visual image interpretation aided by on-screen digitisation was followed. A colour composite was made from Landsat bands 2, 3 and 4, enhanced and geo-referenced. The enhanced corrected image was then displayed on screen for interpretation using GIS software to obtain areas of three land cover categories:

Agricultural land. This includes cropped areas resulting from annual flooding and from pumped irrigation, including herbaceous crops, date palms and other tree crops. Areas were identified and mapped according to colour and pattern. They were easily distinguished from other categories such as water bodies and settlements. They were distinguished from rangeland/desert due to the fact that the images were acquired for the dry season when most of the grasses were dried up. Also, the pattern of agricultural farms is recognised clearly. Irrigated areas within the recession agriculture areas are included. Irrigated areas which were not adjacent to the river and outside of the flooding areas e.g. Gezira were purposely excluded.

Water bodies. These include the Blue Nile and Main Nile, and Roseires reservoir, Sennar reservoir and a very small portion of the upstream end of Lake Nubia as depicted in the satellite images for the dates concerned. These were required for comparison with agricultural areas and for their potential use in estimating water surface evaporation losses, if required.

Settlement areas. These include settlements alongside the Blue Nile and Main Nile, including Greater Khartoum. Leaving Khartoum on one side, these areas are an expression of the population involved in cultivation along the Nile and dependent on the rivers perennial flow and annual flood in a general sense.

Results

The Remote Sensing Authority presented results of the image interpretation and GIS work to establish areas in square metres. These values, and in square kilometres, are given in Table 1.

Table 1 : Remote Sensing Authority's assessment of agriculture, settlements and water body areas along the Nile

Nile Reach	Land Use	Area m^2
Blue Nile Ethiopia/Sudan border to Roseires dam	Agriculture Settlement Water body	2974553.60 29613740.00 272246138.00
Blue Nile Roseires dam to Khartoum	Agriculture Settlement Water body	837913818.22 622701021.40 357078429.00
Main Nile Khartoum to Merowe dam	Agriculture Settlement Water body	1691190048.38 353910422.72 513838039.87
Main Nile Merowe dam to Wadi Halfa (beginning of Lake Nubia)	Agriculture Settlement Water body	1109153045.19 206926241.95 1114895540.22

Source: Original data, Remote Sensing Authority, Khartoum

Quality Control of Results

Before proceeding to use these results, the land use areas for agriculture and water bodies were examined by dividing by river lengths in order to consider average widths of agriculture and the river along the Nile's course. Approximate river lengths were determined from satellite images (Table 2).

Table 2 : Agricultural and river water areas and widths along the Nile

Nile reach between Ethiopian Border and Lake Nubia	River Length	Agricultural Area		River water surface area	
	km	Area km^2	Average width m	Area km^2	Average width m
Ethiopia Border to Roseires dam	100	2.97	30	272.25	2722
Roseires dam to Khartoum	510	837.91	1643	357.08	700
Khartoum to Merowe dam	760	1691.19	2225	513.84	676
Merowe dam to Lake Nubia (Wadi Halfa)	700	1109.15	1584	1114.90	1593
All/total	2070	3641	1759	2258	1090

Source: Remote Sensing Authority, Khartoum.

The average width of the agricultural belt along the Blue and Main Nile is determined as 1.7 km, varying between 30 m upstream of Roseires dam to 2.2 km in the Khartoum to Merowe dam reach. The average widths of the other two reaches are similar, close to 1.6 km. There are no other known estimates of these areas for comparison purposes. These average widths appear reasonable although it is a little surprising that the Khartoum to Merowe dam reach has the maximum average width. It was previously thought that the Merowe dam to Lake Nubia width, including the many islands on which agriculture is practised, might be wider because of the known wide area of farming in the Dongola, Baruda and Argo areas.

The average width of the river channel water surface (as in November and December 2001 images) along the Blue and Main Nile is determined as 1.09 km. It may be noted that Roseires reservoir accounts for the excessively wide water surface between the border and Roseires dam; the reservoir is 8 km wide in some places. This causes exaggeration of the average width of the river itself along its full length.

However, the average width of the river between Merowe dam and Lake Nubia, at 1.59 km, appears unexpectedly high. Independent checking of widths of the most braided reaches on other satellite images, and the aggregate widths of these north of Dongola, rarely produces widths exceeding 1 km and only for relatively short distances. As the results stand for this reach, the river is as wide on average as the agricultural belt alongside the river on average. This appears somewhat difficult to understand and will need to be re-examined in any further work. It seems possible that the water surface area determined for this reach may include many areas of braided river channels, some having and some not having water in the 2001 images.

The adopted riverside “agricultural land” areas that are considered to be dependent on the Nile’s annual flood for their vegetation cover (including irrigation areas within the alluvial belt, but not major irrigation schemes) are given in Table 3. These are considered in Chapter’s 5 and 7 in the main report.

Table 3 : Agricultural land areas along the Nile

Nile reach between Ethiopian Border and Lake Nubia	Agricultural Area km^2
Ethiopia Border to Roseires dam	3
Roseires dam to Khartoum	838
Khartoum to Merowe dam	1,691
Merowe dam to Lake Nubia (Wadi Halfa)	1,109
All/total	**3,641**

Appendix 5.2
Flood Damages in Sudan

Extracts from "An Initial Rapid Appraisal Of Flood Damages Along The Blue And Main Nile Rivers In Sudan, Draft – Version 2". Michael Cawood & Associates Pty Ltd, November 2005. Report prepared for World Bank, Africa Region, Nile Coordination Unit.

The above document was made available to the Consultant at the Cairo workshop in July 2007 in order to consider some Blue and Main Nile flood damage cost data and thereby strengthen the flood alleviation benefit (a secondary benefit) of the Mandaya hydropower project.

The following report sections are presented below

- Executive Summary
- Method Used To Assess Damages
- Study Areas
- Results

These are followed by summary information extracted from the report on the extent of flooding and damages in 1998, and some details of the assumptions underpinning the analysis.

Executive Summary

Introduction

This study has been completed for the World Bank and provides an initial rapid assessment of damages caused by flooding in the Blue and Main Nile Rivers in Sudan. Damage associated with flooding along the While Nile or caused by flash flooding within the river corridor has not been included in the estimate. It is however recognised that flash floods can and do damage villages, local infrastructure and irrigation distribution canals and thus impact heavily on agricultural production and associated losses. Similarly, the cost of disease following flood has not been included specifically in the assessment even though it is acknowledged that this can result in substantial loss.

No attempt has been made to quantify flood benefits, environmental impacts or loss of life costs.

The Rapid Appraisal Method

The study uses the Rapid Appraisal Method (RAM) developed by Read Sturgess and Associates (DNRE, 2000) to assess flood damages. The method is founded on unit damage costs being applied in order to estimate the damages that would occur with floods of different return intervals and accounts for both direct and indirect damages.

It is cautioned that the evaluation of flood damages using the RAM is not an explicit process and involves considerable judgement by the assessor. Consequently, the estimates of economic impacts reported herein should be considered as having a wide confidence range: perhaps of order plus or minus 25 per cent or more. In the current environment, considerable and detailed field work would be required to reduce this confidence range and thereby improve the accuracy of the flood damage estimates. However, that would represent a departure from the fundamental concepts of rapid appraisal.

A strong seasonal pattern was noted on flow and stage data obtained for all key river gauging stations within Sudan with 30% of annual peak flows (ie. flood peaks) occurring in July and the remaining 70% occurring in August. This evidence of a highly predictable 'flood season' has significant implications for damage estimates as it suggests that agricultural damages from Nile flooding are likely to be relatively small for events that are within 'normal' expectations but that larger floods would have a more pronounced impact.

Further analysis of the flow and stage records revealed that at Khartoum and most other downstream locations flows associated with recent large floods are less than earlier annual peak flows. This suggests that the bottom ends of the Blue Nile as well as the Main Nile are subject to substantial bed movements and may in fact be losing flow carrying capacity. The continuing shift in time between the year of maximum flow and the year of maximum height at gauging stations (other than perhaps at Hasanab) adds support to this observation and implies that the impact of the annual flood may indeed be getting worse: an increasing incidence of flooding, more damage to villages, infrastructure and other susceptible floodplain activities and a growing annual flood damage bill.

Following further analysis, discussion and consideration of community recollections of past floods and their local impacts, the 20% AEP (i.e. 5-year ARI) flood event was adopted as the event likely to initiate damages. It was further assumed, for the purposes of this analysis, that this flood would initiate damage along the full length of the Blue and Main Nile Rivers. This is an obvious over-simplification of what happens in practice but provides a marginally conservative starting point for this assessment.

As an extension to the above, it was further assumed that there are no flood related damages below the 20% AEP (5-year ARI) event and that the 1998 flood was representative of a 5% AEP (20-yearARI) event along the Blue and Main Niles.

Damage Estimates

Application of the RAM resulted in an estimate of **US$527 million for the 1% AEP (100-year ARI) event** and an **Average Annual Damage (AAD) estimate of US$52 million per year.**

Data Availability

One of the largest challenges faced by this study was the issue of data and information on Nile River flood damages, or rather the lack of it. While a variety of flood related data and information is collected within Sudan each year there does not appear to be a consistent or structured approach to its collation, consolidation and storage. A range of agencies collect and report on flood costs and damages but due to the different focus of and reporting standards and requirements within these agencies, it becomes very difficult to build a clear and consistent picture of annual flood damages/costs. Further, what data is available is generally consolidated into sector or damage type across the country without differentiation between river basins or between damage caused by flash or longer term flooding.

A further significant challenge faced by this study was the absence of topographic small interval contour maps and historic flood extent maps. In digital form these maps could have been overlayed on other Geographical Information System (GIS) layers (eg. land-use and roads, cadastral, etc) to estimate the extent of physical damages caused by historic floods and the estimated 1% AEP (100-year ARI) event.

Future Work

It is suggested that a program of work aimed at overcoming some of the difficulties experienced in undertaking this study could be initiated in the near future. Specifically, the work would be aimed at:

- Identifying communities/areas/assets at-risk from flood along the Blue and Main Nile Rivers;
- Re-quantifying potential flood damages;
- In satisfying the above, developing a GIS-based tool that allowed dynamic identification of at-risk communities/assets/etc for a user-specified flood level;
- Communicating to communities/agencies the level of flood likely to lead to local damage/threat;
- Improving national and community-based flood response; and
- Reducing actual flood damages.

A Final Comment

The results of this study have potential to add valuable insight to delivery on the Flood Preparedness and Early Warning Project and the Multi-Purpose Project being initiated within the Eastern Nile countries. However, it is stressed that the analysis described herein and the results produced represent an initial rapid assessment. Neither the methodology used nor the results produced are purported to be definitive – they are aimed at providing an initial first estimate order of magnitude answer to the vexing question of "what is the damage in Sudan due to flooding in the Blue and Main Nile Rivers".

METHOD USED TO ASSESS DAMAGES

The methodology presented in this section is largely as recommended in the RAM and described by Read Sturgess (DNRE, 2000). The method is based on the application of unit damage costs to generate estimates of the damages that would occur with flood events of different annual exceedance probabilities (AEP). [1]

The method involves the development of a loss - probability curve (eg. see Figure 1) to estimate the average annual damage (AAD) due to flood. The curve is constructed by plotting damages against their probability of occurrence or more accurately, the annual exceedance probability of the flood event that caused the damage. This means that the large damages resulting from a severe flood event are plotted against a low probability while the relatively smaller damages caused by a smaller flood are plotted against a higher probability.

Figure 1 presents a loss - probability curve based on three known points; namely:

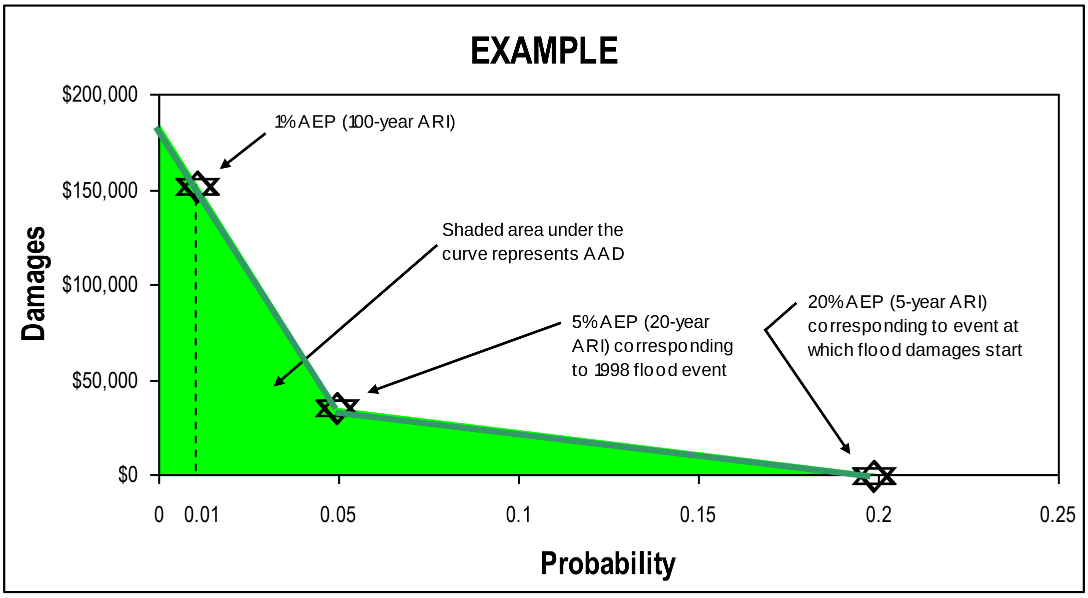
- Damages based on estimated areas of inundation resulting from the approximate 1% AEP (ie. 100 year ARI) flood event;
- Damages based on areas of inundation associated with a recent severe flood, in this case the 1998 Nile flood which has been assessed as being an approximate 5% AEP or 20-year ARI event within the study area (note that a frequency analysis suggests that the 1998 event was a less than 20% or 5-year event at Khartoum rising to an approximate 4% or 25-year event at Dongola); and

[1] The annual exceedance probability (AEP) is the inverse of the annual recurrence interval (ARI) expressed as a percentage. Hence the 1% AEP event is the same as the 100-year ARI event.

- The AEP event where flood-related damages are judged to start (in this case a 20% AEP or 5-year ARI event).

The area under the curve represents the AAD resulting from all flood events over a long period and is estimated by integrating the full loss-probability curve.

Figure 1: Use of loss-probability curve to calculate average annual damages



In accordance with accepted practices for estimating flood damage costs, a distinction is made in the RAM between three groups of damages as follows:

- **Direct (tangible) damages** – these result from physical contact of flood waters with damageable property (eg. damage to the structure and contents of buildings, agricultural enterprises and regional infrastructure);
- **Indirect (tangible) damages** – losses from disruption, as a direct consequence of the physical impact of the flood, to normal physical, economic and social linkages or activities (eg. costs associated with emergency response, clean-up, community support as well as disruption to transport, employment and trade); and
- **Intangibles** – the 'non-market' or social impacts (eg. losses for which market values do not generally exist such as individual/community stress and inconvenience, anxiety, loss of memorabilia, amenity, etc).

Study Areas

This study considered damages resulting from mainstream flooding in the Blue and Main Nile Rivers in Sudan. The analysis did not include damages associated with flash flooding within the Nile floodplain or with flooding in the White Nile.

The Blue and Main Nile floodplains from the Sudan-Ethiopia border to the tail water of Lake Nasser were divided into eleven (11) study areas as shown in Table 3.1 below.

This division was somewhat subjective but was based on a rudimentary assessment of floodplain characteristics including physical character and use. By necessity, the major urban areas of Khartoum (including Tuti Island) and Dongola were assessed separately from their surrounding rural areas.

The floodplains were divided into a series of study areas to assist the calculation of flood damages (refer to Appendix A).

Table 3.1: Study areas along the floodplains of the Blue and Main Nile Rivers

Study Area	Number
Eddeim to Roseires	1
Roseires to Sennar	2
Sennar to Wad Madani	3
Wad Madani to Khartoum	4
Khartoum including Tuti Island	5
Khartoum to Tamaniat	6
Tamaniat to Hasanab	7
Hasanab to Dongola	8
Dongola	9
Dongola to Lake Nasser	10
Roads, buildings, infrastructure	11

Input data and assumptions underlying the estimation of flood damages for each study areas are shown in Appendix A.

RESULTS

Flood damages have been estimated for the Blue and Main Nile Rivers in Sudan using a Rapid Appraisal Method (RAM). The RAM accounts for both direct and indirect damages.

Damages resulting from a 1% AEP (100-year ARI) event are estimated at US$527 million while Average Annual Damage (AAD) is estimated at US$52 million per year. A breakdown of these initial order of magnitude estimates is provided in Tables 7.1 and 7.2.

Note that these estimates do not include any allowance for damages associated with flash flooding nor has an attempt been made to quantify and include flood benefits, environmental impacts or loss of life costs. They do however provide an initial first estimate order of magnitude answer to the vexing question of “what is the damage in Sudan due to flooding in the Blue and Main Nile Rivers”.

Table 7.1: Breakdown of damages by study area

Study area	1% AEP	AAD
Eddeim to Roseires	$0	$0
Roseires to Sennar	$3,584,625	$417,527
Sennar to Wad Madani	$6,206,063	$722,865
Wad Madani to Khartoum	$6,697,350	$780,089
Khartoum including Tuti Island	$13,636,725	$447,241
Khartoum to Tamaniat	$2,383,920	$277,673
Tamaniat to Hasanab	$4,356,000	$507,375
Hasanab to Dongola	$4,378,688	$510,018
Dongola	$87,046,425	$7,499,187
Dongola to Lake Nasser	$0	$0
Roads, buildings, infrastructure	$398,640,600	$40,797,394
TOTAL	**$526,930,395**	**$51,959,369**

Table 7.2: Breakdown of damages by category

Category	1% AEP	AAD
Urban (Buildings)	$22,500,000	$2,200,000
Rural (Buildings & Agriculture)	$149,600,000	$14,800,000
Infrastructure	$3,500,000	$300,000
Indirect	$351,300,000	$34,600,000
Total	**$526,900,000**	**$52,000,000**

Extract of key information on extent of flooding and damages in 1998

Extent and Damages – 1998 flood – along Blue and Main Nile
119,000 houses were flood affected;
331 public buildings (eg. 272 schools, places of worship, medical centres, large non-residential buildings, etc) were damaged;
Approximately 0.3% of the buildings damaged were public buildings;
Around 1,000,000 people were affected and well over 100,000 displaced;
Approximately 1, 011 km^2 of floodplain used for agriculture was affected;
20% of the date palm stock was destroyed;
Large numbers of livestock were lost due to drowning and subsequent disease;
The recovery effort cost US$ 230 m;
Emergency drugs cost US$ 230,000;
Sanitation supplies and works post-event cost US$ 500,000;
US$ 400,000 was spent on replacing seeds and pumps; and
Awareness and education programs cost $ 5,000.

Details of the assumptions underpinning the analysis

Details of the assumptions underpinning this analysis
The 1998 flood is representative of a 5% AEP (20-year ARI) event along the Blue and Main Niles;
No flood damages upstream of Roseires or downstream from Dongola regardless of flood size;
An average of 1,000 houses in the 197 villages that occupy the Blue and Main Nile floodplain;
Average occupancy per house is 5 persons;
53% of houses in all villages were damaged in the 1998 flood; this number will increase by 30% for a 1% AEP (100-year ARI) event;
There are 30,000 houses in and around Dongola;
40% of houses at Dongola were damaged in the 1998 flood; this number will increase by 70% for a 1% AEP (100-year ARI) event;
The 1998 event damaged 50 houses in and around Khartoum and Tuti Island; this number will rise to 3,800 in a 1% AEP (100-year ARI) event as a 1% Blue Nile flood at Khartoum will affect a significant portion of Omdurman and an area on the west bank of the White Nile upstream of the Nile confluence (due to backwater) as well as Tuti Island and communities downstream but will not affect major buildings or assets within the city;
Within urban areas, 30% of flood damaged houses are of mud brick construction while the remaining 70% are made with clay bricks;
In rural areas, 70% of flood damaged houses are of mud brick construction while the remaining 30% are made with clay bricks;
10% of public buildings damaged by flood are of mud brick construction while the remaining 90% are made with clay bricks;
The number of public buildings damaged in a 1% AEP (100-year ARI) is in percentage terms the same as for the 1998 event (ie. approximately 0.3% of other buildings damaged);
No specific allowance for flooding of business premises and/or loss of trading stock;
The area of agricultural land affected by a 1% AEP (100-year ARI) event is 10% more than for the 1998 event; and
Dryland pasture and dryland crops are not affected by flood – at any level.
Note that:
Off-river irrigation schemes have not been considered by this analysis and are thus not factored into damage calculations as in general they are, with the exception of their pumps, protected from Nile flooding, except when distribution canals are damaged by local flash flooding; and
Substantial backwater flooding that extends up tributary streams when the Nile is in flood has not been included in the analysis.

Appendix 6.1

MANDAYA HYDROPOWER PROJECT – CO_2 EMISSION

1. MANDAYA HYDROPOWER PROJECT – CO_2 EMISSION

1.1 INTRODUCTION

The proposed Mandaya hydropower project on the River Nile in Ethiopia offers potential for generating low priced and reliable energy to support regional economic growth. In the following sections the CO_2 emissions resulting from the project's construction activities and the decomposition of biomass in the project reservoir are quantified and compared with the potential CO_2 emissions from generating the same electrical energy through burning fossil fuels.

1.2 CO_2 EMISSION BY THE MANDAYA HYDROPOWER PROJECT

The CO_2 emission associated with a hydroelectric power project are those produced during the manufacture and construction of the project structures and equipment and those produced by slowly decomposing biomass in the reservoir during the project's lifetime.

1.2.1 CO_2 Emission related to Construction

It is well known that the implementation of a hydroelectric power plant involves considerable construction activities and large quantities of construction materials which, in turn, require a large energy input. For the construction of the Mandaya the required quantities of major construction materials and consumables are summarized in Table 1.

Table 1: Quantities of major Construction Materials and Consumables

MATERIALS / CONSTRUCTION	QUANTITIES
Civil Works	
- Soil excavation	5,075,000m^3
- Rock excavation	1,972,000m^3
- Roller compacted concrete	15,000,000m^3
- Conventional concrete	981,000 m^3
- Reinforcement steel	77,000 tons
- Diesel fuel	172,000 tons
Electro-mechanical equipment	
- Steel	30,000 tons

Based on the volume of concrete and other construction activities such as grouting, shotcreting, etc. a cement requirement of about 2,150,000 tons is calculated. The production of one ton of cement requires approximately 4 GJ of energy. Hence the energy input for all concrete works results in approximately 8,560,000 GJ.

The weight of reinforcement steel, hydraulic steel structures and steel for the electro-mechanical equipment totals about 107,000 tons. It takes approximately 40 GJ of energy to produce one ton of steel. Therefore, the energy input into steel and equipment is about 4.3 million GJ.

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 172,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix as described below (coal/gas = 50/50 per cent) then some 222,000 tons of coal and 146,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 1,000,000 tons.

The burning of 172,000 tons diesel fuel will result in a CO_2 emission of about 557,000 tons. The total emission of CO_2 associated with the construction of the Mandaya hydropower project will thus be approximately 1,570,000 tons.

1.2.2 CO_2 Emission caused by the Biomass with the future reservoir

The Mandaya hydropower project will inundate a gross area of about 736 km^2, which, after exclusion of the existing river channel, will result in a net area of about 700 km^2 of land. The biomass of open woodland is in the order of 60 t/ha dry weight and, based on this assumption a total biomass of about 3,600,000 tons (dry weight) is estimated.

All living plants grow by absorbing water and carbon dioxide to form reserves of carbohydrate, known as biomass. This process is fuelled by sunlight and is termed photosynthesis. In simple terms the process is as follows:

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2\uparrow$$

When plants die, decomposition by oxidation takes places which is the photosynthesis process in reverse:

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

The same amount of CO_2 absorbed during photosynthesis is released during complete oxidation of the biomass.

By considering molar weights, one ton of carbohydrate produces 1.47 tons of carbon dioxide during complete decomposition as follows:

$$180\text{ g } C_6H_{12}O_6 + 192\text{ g } O_2 = 264\text{ g } CO_2 \uparrow + 108\text{ g } H_2O$$

$$1\text{ t } C_6H_{12}O_6 + 1.07\text{ t } O_2 = 1.47\ CO_2 \uparrow + 0.6\ H_2O$$

Using the same relationship on the total estimated quantity of biomass affected by the Mandaya hydropower project the decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 2,600,000 tons, assuming that 50% of the woodland was used cut and as fuelwood.

1.2.3 The Total CO_2 Emission of the Mandaya Hydropower Project

Approximately 1,570,000 tons of CO_2 will be produced with the construction of the Mandaya hydropower project. The maximum potential CO_2 emission associated with the aerobic decomposition of the biomass located in the reservoir is estimated to be approximately 2,620,000 tons. Thus the implementation of Mandaya hydropower project will lead to a total CO_2 emission of about 4,200,000 tons.

1.3 CO_2 EMISSION BY equivalent THERMAL POWER PLANTS

This section quantifies the CO_2 emissions resulting from generating the same average energy as Mandaya but by burning fossil fuels. Present thermal plant technology does not include the recovery of carbon dioxide from flue gases. Hence the carbon content of the fuel and the efficiency characteristics of the thermal plant are the governing parameters in calculating CO_2 emission levels. The following formula may be used to compute the CO_2 emission from fossil fuels:

$$CO_2 = A \times (B + C \times HV)$$

where:

CO_2 = emission of CO_2 in metric tons per ton of fuel;

A = multiplier for indirect emissions (exploration, mining);

B, C = regression constants for the particular type of fuel;

HV = lower calorific value of fuel in GJ/ton.

Typical CO_2 emissions for various type of fossil fuel are shown in Table 2. Approximate CO_2 values per MWh delivered to the grid would be as shown in Table 3 for various types of power plant.

Table 2: Typical CO_2 Emissions for various Type of Fuel

Fuel Type	A	B	C	HV (GJ/ton fuel)	CO_2 (ton/ton fuel)
Lignite	1.08	0.20090	0.08693	7	0.87
Coal	1.06	0.20090	0.08693	29	2.90
Oil	1.04	2.50291	0.01494	41	3.24
Gas	1.01	0.55159	0.04463	44	2.53

Table 3: Approximate CO_2 Emission per MWh for various Types of Thermal Power plants

Plant Type	HV (GJ/ton fuel)	CO_2 (tons/ton fuel)	Efficiency (per cent)	CO_2 (ton/MWh)
Lignite-fired steam	7	0.87	36	1.24
Coal-fired steam	29	2.90	37 - 39	0.97
Oil-fired steam	41	3.24	38 - 40	0.75
Gas-fired combined cycle	44	2.53	48 - 52	0.43

Note: Efficiencies shown include station consumption.

The annual average energy to be generated by the Mandaya hydropower project would amount to 12,119 GWh/yr. If the same quantity of energy was to be generated by a thermal mix consisting of 50 per cent coal-fired and 50 per cent gas-fired combined cycle power plants, some 8.5 million tons of CO_2 would be discharged to the atmosphere annually as shown in Table 4.

Table 4: Approximate CO_2 Emission of equivalent Thermal Power Mix

Plant Type	Annual Energy GWh	CO_2 Million tons
Coal-fired steam	6,060	5.88
Gas-fired combined cycle	6,060	2.60
Total	**12,119**	**8.48**

It is noted that the CO_2 emission of 8.48 million tons annually is related purely to the fuel consumption (equal proportions of coal and gas) and does not include the CO_2 emission related to the construction of the thermal power plants.

Assuming that the annual average energy generated by the Mandaya hydropower project would be generated by an "environmentally friendly" gas-fired combined cycle power plant only, which is a most optimistic scenario, then the annual CO_2 emission into the atmosphere would be approximately 5.2 million tons.

1.4 CONCLUSION

The energy sector is the greatest single source of CO_2 emissions into the atmosphere and within that sector the burning of fossil fuels to generate electricity accounts for some 25 per cent of global warming. The Mandaya hydropower project will produce an average of 12,119 GWh of electrical energy annually. During construction of the project, energy is required to manufacture cement and steel and to excavate and construct the project structures. The generation of this energy will result in the release of CO_2 into the atmosphere. During operation of the project, the biomass submerged within the reservoir will slowly decompose also releasing CO_2 into the atmosphere. The estimate of the total quantity of CO_2 released into the atmosphere during construction and operation of Mandaya will be some 1,570,000 tons.

Generating the same energy by burning fossil fuels (equal proportions of coal and gas) would release into the atmosphere some 8.48 million tons of CO_2 every year. Over a period of 50 years, the assumed commercial life of Mandaya, this annual CO_2 emission would result in a total of 424 million tons of CO_2.

Consequently the generation of hydro-electric energy at Mandaya will result in CO_2 emissions 100 times less than if the same energy were generated by burning fossil fuels.

Appendix 6.2

Compensation procedures in Sudan and Egypt

Introduction

Construction of the power trade investment program's hydropower project(s) on the Abbay river in Ethiopia, and transmission lines in Ethiopia, will create the need for compensation to be paid to project affectees, and the need for established grievance procedures to be made widely known. The principles and procedures in Ethiopia are summarised in Sections 6.5 and 9.7 respectively in the main report.

Construction of the investment program's transmission lines in Sudan and Egypt will similarly create the need for compensation to be paid to project affectees, and the need for established grievance and appeal procedures to be made widely known.

These procedures will be required for other issues also in Sudan and Egypt. These relate to various impacts along the Nile caused by river regulation in Ethiopia and not by land acquisition in Sudan and Egypt. Some of these river regulation impacts may require mitigation in the form of monetary compensation with and without land acquisition in Sudan and Egypt.

Compensation procedures in Sudan

Environment and social justice enjoy the protection of the 2005 Interim National Constitution of the Republic of the Sudan wherein Article 43 (2) gives the national government the right to expropriate land for development purposes and to compensate owners.

Specific details and procedures to be followed in the acquisition of land and rules governing payment of compensation for land for public purposes are found in the Land Acquisition Act,1930.

The procedures for land acquisition in any locality are initiated with a notification by the People's Executive Council in a Gazette stating that it appeared to the President of the Republic to authorize the acquisition of land for public purposes (Section 4). It is only after such notification that it shall be lawful to enter into, bore, set out boundaries, mark or survey the land.

An appropriation officer appointed by the People's Executive Council would notify the occupant of land about the declaration that a designated area of land is to be appropriated for public purposes; call upon persons claiming compensation to appear before him at a place and time (not earlier than fourteen days) and to state the particulars of their claims for compensation (Section 10). He must attempt to agree on the amount of compensation for the land.

The Land Acquisition Act, 1930, also provides for further steps to be taken with regard to assessment of compensation if agreement is not reached.

Chapter 2 of the main report provides additional description of the 2005 Interim National Constitution wherein Article 43 (2) gives the national government the right to expropriate land for development purposes and to compensate owners, and description of the Land Acquisition Act 1930.

For compensation that does not involve land acquisition in Sudan (e.g. in relation to pumped irrigation mitigation, river morphology changes), it is anticipated that this will also be assessed during project preparation studies and provision made by the power trade investment program for its disbursement, utilising well prepared procedures which will be made widely known. Compensation matters may be handled by a specially established office for this purpose or by State authorities. In the case of a claim being made outside of the project's assessment, an individual or community's claim for compensation may be forwarded either directly to the State Director of the Ministry of Agriculture, Animal Resources and Irrigation or indirectly via the Commissioner of the Locality where the affected land is located. Then it might go to the Federal Ministry of Irrigation and Water Resources in Khartoum.

The precise mechanisms, and the grievances procedure, require to be determined as a result of further consultations.

Compensation procedures in Egypt

Law No. 63 (1974) provides for obtaining Right of Way for the construction of transmission lines and for landowners to obtain compensation. Financial compensation is decided by committee members from representatives of the Ministry of Agriculture, the electricity sector, an Egyptian Surveying Authority and the local Governorate. In the event of a landowner not agreeing with the committee's decision, he has the right to appeal in Court.

If the landowner refuses construction of lines on his land, the Minister of Electricity and Energy issues a ministerial decree, published in the official Gazette, in order to permit the construction work to be executed by force.

Compensation normally covers the value of affected cultivated crops during construction works and the value of land occupied by tower foundations.

In the cases of mitigation for the additional lifting of irrigation water when Lake Nasser levels decrease because of the project in Ethiopia, compensation will be required for the additional pumping energy costs, provision of floating pumps, and land preparation works (land levelling, new irrigation channels, etc). Similarly, compensation by money or by physical mitigation measures (e.g. fishing boats, new paved access roads, jetties, destination points, fishermen's residence facilities) may be expected for any adverse impacts on lake navigation and fisheries.

In the case of reduced power generation and energy sales at High Aswan Dam, compensation will be payable by the project in one form or another. This may be in monetary terms and/or by energy substitution with an equivalent supply being provided to the Egyptian grid from the Abbay hydropower development.

Future studies will assess the legal framework, all types of compensation and alternative mitigation measures and will elaborate the probable negotiation and grievance procedures by concerned parties.

APPENDIX 12

TERMS OF REFERENCE FOR ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF MANDAYA HYDROPOWER PROJECT

1. INTRODUCTION

The Final Report of the "Pre-feasibility Study of the Mandaya Hydropower Project" (Chapter 15 of the engineering report) makes various recommendations and proposes Terms of Reference for a feasibility study of the Mandaya project.

This appendix reproduces the engineering report's general recommendations (Section 2) and recommendations concerning a Blue Nile optimisation study (Section 3). These set the scene and have an important bearing on the sequence and content of future engineering and ESIA studies.

The appendix then identifies 11 components of future ESIA studies associated with Mandaya (Section 4).

Section 4.1 considers the prior need for a Blue Nile optimisation study which will assist determining a strategy for development of the Abbay hydropower cascade in the light of first filling and operational impacts in Sudan and Egypt. Terms of Reference for this study are not developed but may be expected to be similar to but more wide-ranging than those presented in Section 4.11. Following sections make the working assumption that feasibility studies of Mandaya will follow the optimisation study.

Section 4.2 presents the draft scope of works for Terms of Reference for the overall ESIA study. These are structured to recognise the various components which will feed into the main ESIA report. Section 4.2 therefore has some general or "umbrella" parts applicable to all components, and some detailed parts referring specifically to works in the Mandaya project area in Ethiopia only.

Sections 4.3 to 4.10 refer to various study components of the overall ESIA, stating what works are expected and how they will be arranged. For the very wide-ranging study areas concerning river morphology and conversion of flood recession agriculture to pumped irrigation, detailed study objectives are given which, when considered in Sudan and by ENTRO, may be adjusted and converted into Terms of Reference. The large scale of these important study areas is emphasised.

Section 4.11 refers to river system and ESIA studies concerning Mandaya, Sudan, Lake Nasser and Aswan. It presents a first draft scope of work of Terms of Reference for development and use of existing simulation models for investigating multiple permutations of first filling conditions and impacts in the operational period. The required principal data sets are described and the characteristics of iterative simulations are presented. It is observed that the types of simulation work described for the Mandaya feasibility study in the draft Terms of Reference are similar in principle to those required for the Blue Nile optimisation study in Section 4.1 where the latter would investigate all elements and sequences of development of the potential Abbay cascade, not Mandaya alone.

Three Annexes on ESIA reporting formats and contents of the African Development Bank are included to support this Appendix.

Section 4 of this appendix sets out what is considered to be required in the scope of work of the main ESIA report, in the very extensive major components relating to river morphology and conversion of flood recession agriculture to perennial irrigation, and in the smaller constituent components.

It is believed that all of these cannot now be, and should not be, integrated into a single stand-alone document which would have common introductory and final sections wrapped around the scope of works for all components. The reasons are as follows:

1. The subject areas requiring studies are very wide ranging, involving many organisations. They require much further consideration by ENTRO PCU and stakeholders before they can evolve into one or more stand-alone documents. Without such consultations, any attempt to produce a single, consolidated, comprehensive stand-alone document incorporating all of the components may be expected to fail and will not therefore serve a practical purpose.

2. It is considered more useful and more appropriate to outline the components, show how they combine and contribute later to an ESIA report (Table 1) and declare the scopes of work as drafts at this stage.

3. The Blue Nile river optimisation study is regarded as a completely separate study from Mandaya's ESIA study. It will be carried out before Mandaya's ESIA study. It may confirm Mandaya as the first of three or four hydropower studies in the Abbay cascade, and it may not.

4. The river morphology study requires very detailed preparation with full consultations in Sudan, and with Egyptian experts because of Egypt's experience of river morphology changes downstream of Aswan. It is a study which lends itself to being carried out independently of the ESIA and it would be helpful for progress to be made on it in advance of feasibility and ESIA studies of Mandaya. The morphology study requires its own ESIA reporting. The study's scope of works (drafted here) requires thorough examination and adjustment, with its full TORs having their own introduction, background information, objectives, consulting team requirements, schedule, etc.

5. Similarly, the study of conversion of flood recession agriculture to perennial irrigation requires very detailed preparation with full consultations in Sudan, and with Egyptian experts because of Egypt's experience of this downstream of Aswan. It is a study which requires pre-feasibility and feasibility stages, leading to engineering design ready for implementation if found feasible and socially acceptable. This is a very important study of what would be a major undertaking. The engineering/irrigation study requires its own ESIA reporting.

Its scope of works (drafted here) requires thorough examination and adjustment, with its full TORs having their own introduction, background information, objectives, consulting team requirements, schedule, etc.

6. Finally, reference may be made to the ENPTPS' Strategic Environmental and Social Assessment report, prepared immediately after submission of pre-feasibility study reports. This recommends for consideration three categories of work areas, and implies that considerable time and consultations are required before the complexities of the ENPTPS next studies can be resolved and financed. It is therefore considered to be premature to produce consolidated TOR documentation at this stage. Nevertheless, the draft scopes of work which follow should serve the purpose of guiding consultations and producing TORs in the near future.

2. GENERAL RECOMMENDATIONS

Chapter 15 of the engineering report makes the following general recommendations:

"The three largest hydropower projects identified in Module 3 for Ethiopia are all in the least-cost generation expansion plan determined by the Consultant. On the basis of present available studies (pre-feasibility studies) for Mandaya, Karadobi and Border, Mandaya is potentially the project with the lowest economic cost. Considering the time necessary to carry out feasibility study, detailed study, call for tender, construction, the earliest date of commissioning for these projects is in the range of 2020-2025, which is about the time when the first large hydro project is needed in the Ethiopian generation expansion plan (depending on demand projection and export scenario to Kenya).

Accordingly, the Consultant recommends to carry out the feasibility study of Mandaya at the earliest, in order to confirm whether Karadobi or Mandaya presents the most overall benefits.

The Consultant also recommends to carry out the feasibility study of Border, which although being ranked after Karadobi and Mandaya, might be one of the most interesting large hydro projects in Ethiopia".

3. BLUE NILE RIVER OPTIMISATION STUDY

Chapter 15 of the engineering report makes the following recommendation:

"The Blue Nile river scheme, mainly composed of Karadobi, Mandaya, Border and Beko Abo projects, has the potential to become one of the main sources of power export in the region in the next 15 years.

The first three of these projects have been studied to pre-feasibility stage, each pre-feasibility study being obviously focused on each project, while including some analysis of downstream impact and relative impact of one project to the other. Furthermore, these studies were carried out independently of the Ethiopian power demand evolution, assuming that all the generation will be absorbed by the power system.

The Consultant recommends to be carried out a Study of the overall Blue Nile river scheme whose objective would be to optimise the overall design of the Blue Nile hydro scheme: size of reservoirs, installed capacities, operation strategy, schedule of commissioning, filling strategy, overall downstream impact analysis during filling and operation.

This Study should consider the overall supply/demand balance of Ethiopia (including export) and its evolution, and possibly the overall supply/demand balance projection of Sudan (including irrigation need, evaporation, etc)".

4. COMPONENTS OF ESIA

This Initial Environmental Impact Assessment report has highlighted the need for detailed studies in Ethiopia, Sudan and Egypt where impacts require mitigation/enhancement, recognising that the Mandaya project is on an international waterway.

It is necessary for future studies to not only address mitigation and enhancement measures in specific terms but to estimate mitigation costs and enhancement benefits in monetary terms so that they may be taken into account in the project's economic and financial analyses.

Some of the proposed mitigation works are, or may be, major engineering undertakings. They have been described in general terms in this initial environmental impact assessment report but they have not been studied in detail. For the Mandaya project (or any other hydropower project) to become "bankable", all mitigation works have to be thoroughly studied, shown to be both feasible and acceptable to all parties and ready for implementation according to the project schedule. Moreover, some mitigation works will create their own impacts and these have to be studied and taken into account.

Following the conclusions reached in Chapter 12 of this report, future ESIA work may be classified into various components. Eleven components are listed in Table 1. Each component is described in subsequent sections.

Table 1 : Environmental and social components of Mandaya feasibility study

Component No.	Component of Mandaya studies	Type of Study required	Main Location for study component	Comment on environmental and social components
1	Blue Nile Optimisation Study	Eastern Nile System study to test and recommend strategy	Blue Nile cascade and downstream to Lake Nasser and Aswan	Emphasis needed on schedule of commissioning, filling strategy, and overall downstream impact analysis during filling and operation
2	**Mandaya hydropower project**	**Engineering and ESIA**	**Ethiopia**	**Main ESIA report with RAP, including integration of summary results of component numbers 1, and 3 to 11**
3	Mandaya's transmission lines	Engineering and ESIA	Ethiopia, Sudan, Egypt	**ESIA** (Phase 2 of current study). Carry forward summary and costs to No.2
4	Increased energy generation in Sudan hydro power cascade	Engineering simulation without and with Mandaya. Establish benefits. ESIA of changed flow regime.	Sudan hydropower cascade, especially Roseires	**ESIA** of changed flow regime. Carry forward summary and energy benefits and other costs/benefits to No.2
5	Reduced sediment transport and reduced dredging costs	Engineering. Establish benefits.	Sudan power cascade	Carry forward benefits to No.2
6	Reduced sediment transport, raised dry season flows and raised dry season river levels at irrigation schemes and water supply treatment works	Agricultural and engineering. Establish benefits	Sudan irrigation schemes and water supply treatment works	Carry forward benefits to No.2
7	Reduced sediment transport and reduced pump maintenance/replacement	Engineering. Establish benefits.	Sudan. All pumped schemes	Carry forward benefits to No.2
8	River morphology	Engineering and ESIA. Establish costs.	Blue and Main Nile in Sudan	**ESIA** of mitigation works. Carry forward summary and costs to No.2
9	Reduced urban and related property flooding	Engineering. Review and update flood damage costs. Establish benefits.	Blue and Main Nile in Sudan	Carry forward costs to No.2
10	Conversion of flood recession agriculture to pumped irrigation	Engineering and ESIA	Blue and Main Nile	**ESIA**. Carry forward summary and costs and benefits to No.2
11	First filling and river regulation impacts on Lake Nasser/Nubia	Engineering and ESIA	Aswan and Lake Nasser/Nubia	**ESIA.** Carry forward summary and costs to No.2

4.1 BLUE NILE OPTIMISATION STUDY

As stated in the engineering report and repeated in Section 3 above, the Consultant recommends a study to optimise the overall design of the Blue Nile hydropower cascade: size of reservoirs, installed capacities, operation strategy, schedule of commissioning, filling strategy, and overall downstream impact analysis during filling and operation.

Thus, this optimisation study is about determining the sequence and strategy for development. It is envisaged that the study will develop and utilise one or more river system simulation model(s) to investigate an array of storage development scenarios in Ethiopia and impacts downstream. Among the key overall issues raised by the pre-feasibility studies and workshops in Khartoum and Cairo in 2007 is the impact on Lake Nasser/Nubia of first filling and operating one reservoir on the Abbay, and then a second, third and perhaps a fourth reservoir.

The optimisation study will need to investigate and highlight the benefits and disadvantages of a cascade development holding back say 49.2, 89.4 and 103.9 billion m^3 in Abbay storages (cumulative gross storages at full supply levels currently proposed, Table 2) and alternative storage quantities, and examine the impacts at Aswan (power generation and releases) and in and around Lake Nasser/Nubia (fisheries, agriculture, pumped water supplies for irrigation and domestic supplies, navigation) during first filling and during operation of storage development sequences in Ethiopia.

Table 2 : Potential Abbay storages, cumulative storages and Lake Nasser/Nubia storage zones

Reservoir	Gross storage Billion m^3	Cumulative Gross storage Billion m^3
Mandaya	49.2	49.2
Karadobi	40.2	89.4
Border	14.5	103.9
Beko Abo	-	
Compare with HAD, Lake Nasser/Nubia		
@ 147 masl (dead storage)	31	31
@ 147 - 175 masl (live storage)	90	121
@ 175 – 178 masl (flood buffer)	18	139
@ 178 – 182 masl (flood control zone)	23	162

What is clear from Table 2 is that storing up to 49.2 and then 89.4 billion m^3 in Blue Nile reservoirs will markedly reduce the normal live storage contents (121 billion m^3) at Lake Nasser/Nubia. Whilst river regulation releases from the Blue Nile storages, with contingency planning as needed, can ensure the water yield in Egypt is maintained, there is no doubt that reduced levels in Lake Nasser/Nubia will reduce power generation at Aswan and increase pumping costs from the lake for irrigation and water supplies. At the same time, reduced levels and therefore reduced surface areas of Lake Nasser/Nubia should reduce evaporation losses (estimated at 10 billion m^3/year) and permit significant savings in these losses and their conversion to usable water supplies.

The principal issue of the Abbay cascade development, with other attendant issues, is about

balancing

- the benefits of generating vast quantities of energy on the Abbay for the region, increasing energy generation in Sudan and potentially increasing usable water supplies at Aswan

with

- reduced energy generation at Aswan and increasing energy costs for pumping from Lake Nasser/Nubia, both resulting from lower lake levels.

This now requires detailed examination in order to better understand and propose a development sequence and strategy on the Abbay. The extensive use of simulation models is seen as the way forward. For Lake Nasser/Nubia, it is fortunate that much lake modelling calibration and research work has been carried out very successfully (some published, some unpublished) and the hydrological impacts of first filling and operational scenarios of Abbay storages may be thoroughly investigated by use of existing models, and their adaptation as may be required (Fahmy, 2001).

The energy impacts of this study will be described from simulation model outputs. The environmental and socio-economic component of this study will need to cover cumulative impacts in Ethiopia, Sudan and Egypt, concentrating on Lake Nasser/Nubia.

The scope of work for this optimisation study has not been developed but in essence it is expected to be similar to the scope presented in Section 4.11. The results of this study will inform study components 2 to 11 for Mandaya (if Mandaya is confirmed and selected as a first development in the cascade); alternatively, the results will inform these components for any other first development selected.

4.2 ESIA FOR MANDAYA HYDROPOWER PROJECT

The ESIA for the Mandaya project will require studies in Ethiopia and a series of supporting studies and documentation as described in Table 1. It is envisaged that some of the supporting works may be carried out in advance of studies in the Mandaya area, and others in parallel. Depending on timing, the results of supporting works may require updating for the final EIA documentation.

The following general and specific tasks will be required:

General Activities

These general activities refer to all activities for the main ESIA report, referring to and incorporating summary results of supporting studies in Sudan and Egypt.

- Describe the proposed project by providing a description of the relevant components supported by plans, maps, figures and tables;
- Identify the policy, legal administrative framework as well as institutional arrangements pertinent to the project in Ethiopia, Sudan and Egypt;
- Define and justify the project study areas for the assessment of environmental and social impacts;
- Describe and analyse the physical, biological and socio-economic conditions in the study area before project implementation. This analysis shall include the interrelations between environmental and social components and the importance that society and local populations attach to these in order to identify the environmental and social components of high value and/or those presenting a particular interest;
- Identify and assess potential importance of beneficial and adverse environmental and social, direct and indirect, short and long-term, temporary and permanent impacts, on the basis of a rigorous study mechanism;
- Define appropriate mitigation/enhancement measures to avoid, minimise, mitigate, or compensate for adverse impacts and to enhance the project environmental and social benefits, including responsibilities and associated costs;
- Address potential cumulative effects taking into account other initiatives planned in the study area;
- Develop an environmental and social monitoring program, including indicators, institutional responsibilities and associated costs;
- As appropriate, prepare an environmental hazard plan including an analysis of the risks of accidents, the identification of appropriate security measures and the development of a preliminary contingency plan;
- Prepare a resettlement action plan;
- Identify institutional responsibilities and needs for capacity building to implement recommendations of the environmental and social assessment;
- Carry out and document consultations with primary and secondary stakeholders in order to obtain their views on and preoccupations about the project. These consultations shall occur during the preparation of the ESIA Report to identify key environmental and social issues and impacts, and after completion of the draft ESIA Report to obtain comments on the proposed mitigation/enhancement measures;
- Prepare the ESIA Report according to the requirements of the African Development Bank at the time of study. The current typical contents of an ESIA report are presented in Annex 1 accordingly, and a list of typical environmental and social components and crosscutting issues is presented in Annex 2;
- Prepare an Environmental and Social Management Plan (ESMP) according to the requirements of the African Development Bank at the time of study. The generic contents of ESMP are presented in Annex 3. This management plan shall be presented as a distinct document from the ESIA Report.

- Prepare an implementation plan for environmental mitigation, monitoring and overall management.

<u>Specific Activities in Ethiopia</u>

The following specific activities (a, b, c and d) refer to all ESIA activities for the Mandaya dam project within Ethiopia. (The separate ESIA study and report on project transmission lines, and the studies in Sudan and Egypt, are covered in components 3 to 11).

a) Socio-economic Environment

- Review the physical cultural resources of the project area and recommend a procedure for reporting, documenting and/or salvaging known artefacts found prior to construction, and during the construction period;
- Conduct a population census in the reservoir and surrounding area to determine the number of project affected people (PAP), and their lost properties; project census data forward, as maybe necessary;
- Assess the areas of cultivated and grazing lands related to the project affected area, annual agricultural outputs and values of these;
- Assess the areas of recession agriculture in the reservoir and secondary impact zone of the project and assess the values;
- Assess economic and social infrastructure (public and private) that would be permanently and temporarily affected by the HPP construction and operational activities - these include shops, investments, stores, income generating activities, bridges, road, schools, health facilities;
- Assess the natural resources (e.g. incense, honey, guangules, gold, fish) to which the affected people will be denied access;
- Assess the land use /land cover of the reservoir area and its woredas;
- Assess the existing public and environmental health situation in the project area; obtain data on health facilities available in the project area (physical and staff) and propose additional facilities for serving the project area effectively;
- Identify human and livestock parasites indigenous to the project area and proposed resettlement areas; make proposals for eradicating, avoiding or minimising them;
- Assess water supply and sanitation conditions in the project area and propose additional facilities for serving the project area effectively;
- Assess availability and distribution of public services (e.g. electricity, telecommunications and postal service) and propose additional facilities for serving the project area effectively;
- Assess the existing institutional capacity in the region and recommend measures for institutional capacity enhancement;
- Identify the institutions to be involved in the preparation for and implementation of the development project as per existing legislation, and propose the roles that they will play in the project;

- Identify existing government policies and guidelines which have implications for project development. The constraints that such policies impose on the envisaged development projects, if any, are to be assessed and proposals made for modification of them to achieve effective results;
- Assess manpower requirements and availabilities for various categories of staff for project construction, including reservoir basin clearance, and for project operation;

  In order to design a responsive and proactive set of mitigating measures in the RAP and related development plan, the following points shall be given emphasis.
- Undertake an in-depth study of the social organization of the indigenous inhabitants of the project area. This will include the organizational relationships and interactions with the neighbouring Amhara, Oromia and other communities and describe how the indigenous inhabitants maintain, or struggle to maintain, their organizational structure, modes of production, livelihood and culture;
- The above component will also examine the decision-making processes of the project area society in order to provide in-depth understanding of how community level decision-making norms and institutions operate. This should inform how decisions are made, and the process of making decisions; who decides; the formal and informal institutions for decisions including values that regulate how the potential resettling communities function in their new environment;
- Undertake a study of the history of the relationships of the indigenous people with the neighbouring cultures, provide understanding of the conflicts of the cultures among the ethnic groups;
- Design and put in place a process framework through which the affected communities can participate in the design of project components and determination of measures necessary to achieve resettlement policy objectives. This should recognise that the Gumuz and other ethnic groups in the area are perhaps among the most disadvantaged, poorest, least educated and least integrated in the country.
- Discuss social risks and the effects on the health and well-being of the societies that might arise from ecological stress and the degradation of the environment from the emergence of a relatively large construction town;
- Review and document the experience of resettled people in the project area and other areas which may be considered relevant (e.g. Gilgel Gibe project) and ensure that planning learns lessons from the past;
- Ascertain the attitude of resettlers to modern agricultural practices, innovation, authority, discipline, advice, new technology, risk and participation in planning;
- Investigate potential areas for resettlement and examine the possibility of including all/part of the potential resettlers as a target group for resettlement in one or more locations, and justify the selection/screening criteria.

- Indicate resettlement development options and discuss each option's technical, socio-economic, and organizational feasibility and socio-cultural acceptability.
- Develop a resettlement action plan, with an associated development plan, according to Ethiopian and World Bank guidelines. *Inter alia,* the plan shall include recommended target incomes to be achieved by dates in a prescribed time schedule, internal and independent monitoring/auditing arrangements, and a clear understanding of the evolution or scheduled hand-over arrangements of project-funded developments (management, monitoring and maintenance) to regional government, communities and others, and the components which will or may require project funding for given periods, or indefinitely.

Finally,

- Describe opportunities for employment and development for the people of the area during the project operation phase, anticipating as much as possible project-induced developments and the infrastructure and planning required for these;
- Estimate the total population that will be beneficiaries of the proposed project;
- Estimate all project socio-economic costs and benefits (capital and recurrent, direct/indirect, tangible/intangible) resulting from the project’s development in quantitative terms as far as possible, including contingencies for residual liabilities.

b) Institutional Set-up

Notwithstanding references to institutions, policy frameworks and plans in a. above

- Describe the mandate and structure of key organizations that are responsible for the activities relating to the hydropower development and environmental issues of Mandaya HPP;
- Identify federal and regional institutions that should be part of the projects proposed in the ESIA feasibility study for implementation, planning, coordination and monitoring;
- Identify the relevant legal and policy framework for project implementation and make recommendations to overcome any identified gaps;
- Devise monitoring and evaluation procedures for implementation of the mitigation options identified in the ESIA study;
- Based on analysis of stakeholders, propose a stakeholders’ network to facilitate information for better implementation of the proposed projects;
- Develop a management plan to mitigate negative impacts of the HHP to acceptable levels; determine the steps required to implement the plan;
- Assess and recommend training needs to implement the projects, with emphasis on training local people for participating and benefiting from the projects.

c) Physical Environment

- Provide a detailed assessment of the physical environment in relation to the project area and proposed engineering works, including access road routes, dam site, quarries, borrow areas, spoil heaps, works camps and reservoir area, and the river channel to the Sudan border. The description shall include, but not be limited to, geology, mineral deposits[1], topography, soils, climate, climate change, surface and groundwater hydrology, including water quality, and suspended sediment transport.
- Develop a water quality simulation model for the reservoir and estimate its water quality characteristics during first impoundment and during the operational period. Utilise river water quality, soils and biomass data in the model to assist the project's final design and to recommend the amount and locations of reservoir basin clearance. (See related matters on soils and biomass sampling in the reservoir area in d. Biological Environment below).
- Assess and report on the current status of all on-going Abbay watershed management activities and programs. Report on the future expectations of these programs and their declared time and funding schedules. Estimate the impacts on sediment transport rates at the dam site of these watershed management programs, ranging from their failure to arrest accelerated erosion through to their proposed levels of success.
- Report on trap efficiencies and rates of reservoir sedimentation adopted in engineering design studies, and the indicated times when sedimentation will begin to impact on firm energy generation and sales;
- Assess and report on ongoing and future autonomous developments in the Abbay catchment area which will or may cause changes in consumptive water use, land use and land cover and thereby affect the Abbay's water and sediment yield at the reservoir site in the medium and long-term (e.g. water transfer to Addis Ababa, storage developments, irrigation development, additional water supplies, woodland/forest conversion, population pressure); summarise how any foreseen reduction in yield is accounted for in engineering studies and in sensitivity analyses in the engineering feasibility study.
- For other impact assessment, management, monitoring and cost estimates relating to the physical environment, see e). below

[1] In the pre-feasibility study, assessment of the geology of the reservoir basin did not reveal known occurrence of existing, or potentially, commercially valuable mineral deposits. However, because of the difficulties of access to the reservoir basin, it is possible that valuable mineral deposits exist. If so, the opportunity cost of inundating such resources should be assessed. This aspect may have been pursued prior to the ESIA study and the results made known. If not, this involves tracing historical and existing prospecting concessions which have been awarded, and discussions with the Ministry of Mines and Energy, the Ethiopian Institute of Geological Surveys, the Ethiopian Mineral Resources Development Corporation, the Ethiopian Investment Authority, and mining companies which have been or may be active in the region.

d) Biological Environment

Aquatic ecology

- Undertake systematic surveys and studies of the aquatic biota of the Abbay river and tributaries in the potential Mandaya reservoir area and of the Abbay and tributaries downstream to the Sudan border. This should include the fish, phytoplankton, zooplankton and benthic organisms and river-related plants, insects, amphibians, reptiles, birds and mammals;
- From sampling of fish and noting their condition in various seasons, describe temporal and spatial migration patterns of migratory fish species from the Sudan border to the upper ends Abbay and Didessa rivers in the potential reservoir area. Distinguish between migrations which are known and those which are estimated. Utilise local observations and knowledge of aquatic ecology, including historical notes and photographs that may be available from fishermen who now live outside the project area, including those who have been visitors to Boka mission;
- Obtain aquatic ecology and fisheries reports for existing reservoirs (Roseires in Sudan, Fincha, others) and interpret these in relation to the study area and proposed development; in the case of Roseires, examine the list of fish species present before and after Roseires reservoir development, and compare with the fish species observed in Abbay and tributaries in the project area; in the cases of Roseires, Fincha and any other reservoirs, historical and current fish stocking trials and practices shall be noted and factors determined which may give rise to algal blooms and weed growth in the future Mandaya reservoir;
- On the basis of surveys and all assembled information, determine the presence of any endemic aquatic species and, if any, comment on the project's impact on them;
- Consider the potential for reservoir and river fisheries development and make proposals for a wetlands management plan incorporating a fisheries development plan accordingly. Full consideration shall be given to the range of reservoir and river operating levels, water quality, reservoir basin clearance, fishing methods and boat, nets and other equipment, one or more fish hatcheries, and markets. The aptitude and interests of local people, and their accommodation, training and health and safety aspects, shall be considered in association with socio-economic studies in developing the plan.
- For other impact assessment, management, monitoring and cost estimates relating to the aquatic environment, see e). below

Terrestrial ecology

- Undertake systematic surveys and studies of the terrestrial ecology of the project area including access road routes, dam site, quarries, borrow areas, spoil heaps, works camps, reservoir area and its buffer zone (say, 1 km beyond proposed full supply level), and along the banks of the river channel to the Sudan border.

- Undertake systematic surveys and studies of the terrestrial ecology of the Dabus Valley Controlled Hunting Area (and any other areas which the Client or Consultant may propose as environmental offset(s) for improved management. These surveys shall include plants, and resting, feeding and breeding habitats of wildlife including bird life. In the Dabus Valley Controlled Hunting Area, arrangements shall be made for sustained observations of bird life in order that its potential for designation as an Important Bird Area may be considered.
- On the basis of surveys and all assembled information, determine the presence of any endemic terrestrial species and, if any, comment on the project's impact on them;
- In the cases of all terrestrial ecology surveys, traverses and spot survey locations shall be mapped and geo-referenced, noting (and photographing) prominent features and specific local names which may permit traverses and spot survey locations to be found again, as may be required;
- Adopt and utilise a vegetation classification system for all surveyed project and related sites, and map accordingly; utilise satellite imagery, air photography and other sources to assist development of project area mapping;
- During traverse surveys in the potential reservoir area, obtain soil samples (for laboratory analysis) and record sufficient information about woody material (e.g. diameter at DBH, rooting system) to estimate biomass in the potential reservoir area, above and below ground level; soil samples shall be analysed for humus material and mineral contents. Biomass and soil sampling sites shall be geo-referenced and mapped;
- During traverse surveys in the potential reservoir area and adjacent buffer zones, in addition to observing/sampling plants, wildlife, wildlife habitats, biomass and soils, the opportunity will be taken to observe and record any outstanding local features which may have a bearing on the proposed development. These may include, but not be limited to, cultivated areas, salt licks for domestic stock or wildlife, river crossing places in dry season, landslides, historical or cultural sites. In all cases, reported features shall be geo-referenced, photographed where possible and mapped, and such information presented in progress reports and made available to all environmental and socio-economic consultants;
- During traverse surveys in the potential reservoir area and adjacent buffer zones, consider, observe and advise on all possible alternative means for contractors to remove woody biomass below the proposed full supply level and haul it to temporary or permanent sites outside of the reservoir area for safe storage at collection sites for onward distribution, or for intended decay (as woody micro-habitat), For this purpose, the reservoir area may be conceptually considered as "departments" with boundaries being ridges or watercourses. Such observations from the survey traverses may assist the planning of reservoir basin clearance, including the noting of residual areas where total or partial clearance may be either completely impracticable, or undesirable;

- During traverse surveys in the potential reservoir area and adjacent buffer zones, and during any other periods of observation (e.g. repeated visits, aerial reconnaissance), observe and record burning and burned-over (previously burned) areas. Provide an interpretation of this in relation to natural fires, and fires purposely caused for shifting agriculture, people's security against wild animals, poaching and any other purposes. In all cases, observed fires and burned-over areas shall be geo-referenced, documented and mapped, and such information presented in progress reports and made available to all environmental and socio-economic consultants;
- Provide detailed description of the various land uses in the proposed reservoir and surrounding buffer zone area;
- Estimate the *in situ* biomass above and below ground level in the reservoir basin, further classifying this for the area below proposed Minimum Operating Level (the dead storage zone) and between Minimum Operating Level and Full Supply Level (the live storage zone)[2].
- Contribute biomass and soil chemistry data, and field observations, to those concerned with reservoir water quality modelling (See c) above);
- According to recommendations resulting from water quality modelling, fisheries development and recreational/aesthetic needs, and practical observations made about the ease/difficulty of clearing woody material, determine the areas to be fully cleared, partially cleared or left untouched.
- Prepare a plan for reservoir basin clearance accordingly, providing a time-frame for all activities to ensure the desired amounts of clearance are achieved before first filling begins. Attention should be paid to all aspects, including close supervision, but special attention should be given to the amount of clearance in the dead storage zone.[3]
- The reservoir basin clearance plan should assess the availability of potential contractors, encouraging the participation of labour forces from woredas adjacent to the reservoir's perimeter.
- Proposals shall be made for wildlife management and monitoring of the reservoir's buffer zones and selected environmental offsets.
- For other impact assessment, management, monitoring and cost estimates relating to the terrestrial environment, see e) below.

e) Impact assessment, management, monitoring and cost estimates

The following activities refer to all ESIA activities for the Mandaya hydropower project within Ethiopia, and for project transmission lines and the mitigation and enhancement issues of studies in Sudan and Egypt.

[2] It is common in hydropower feasibility studies for environmental surveys to be conducted before final decisions are made on a reservoir's minimum operating level (MOL) and full supply level (FSL). Hence, the geo-referencing and mapping of vegetation, habits, samples and other observations made during traverse surveys, and at other times, may contribute to the project design, and permit adjustment of estimates in line with finally adopted MOL and FSL.

[3] Mandaya may take some years to reach MOL during first filling, and water from below MOL will be released to meet downstream demands, at first through low level outlets and later through the mid level outlet. The time depends on the construction schedule. Downstream interests include fisheries at Roseires reservoir.

- For all general and specific tasks listed above, and other construction activities, the consultant shall provide detailed assessment of positive and negative project impacts and mitigation and enhancement measures for these;
- An environmental management plan shall be developed. This may be presented for the whole project or by country (to be determined in consultation with the Client)
- An environmental monitoring plan shall be developed. This may be presented for the whole project or by country (to be determined in consultation with the Client)
- Estimates of capital and recurrent costs and benefits shall be prepared, including those for institutional strengthening.

4.3 MANDAYA'S TRANSMISSION LINES

It is currently proposed by ENTRO to conduct a feasibility and ESIA study of transmission lines and associated works in Phase 2 of the Eastern Nile Power Trade Program Study, beginning in 2008. Terms of Reference are already prepared. As the construction of Mandaya is estimated to take 10 years, the construction of transmission lines and associated works will be scheduled to be operational at the time of commissioning turbines. It is therefore envisaged that the ESIA prepared in 2008/09 will become out of date and require review and updating, especially with regard to compensation cost estimates.

4.4 INCREASING ENERGY GENERATION AND REDUCING RESERVOIR SEDIMENTATION IN SUDAN

As stated in this initial environmental impact assessment report, and in Table 1, the benefits of Mandaya river regulation impacts of increasing energy generation and reducing reservoir sedimentation in Sudan at Roseires, Sennar and Merowe require quantifying in energy and monetary terms.

In practice, if one or more additional hydropower projects in the Main Nile cascade in Sudan is developed within say the next 20 years, the additional benefits of Mandaya regulation should be included also.

The energy benefits for NEC require quantifying and incorporating in the Mandaya project economic analysis. These are essentially engineering matters and it is envisaged the summary results of studies by engineers for the technical feasibility study would be included in the Mandaya ESIA report for completeness.

However, ESIA will be required for the changes in Blue Nile flows upstream of Roseires caused by Mandaya, and in operations of the Sudan cascade in relation to dam safety, river crossing safety issues, river and reservoir fisheries impacts and costs and benefits associated with these reservoir operations. Thus the following ESIA Terms of Reference are proposed to cover these works:

- Describe the existing physical, biological and socio-economic environment along the Blue and Main Nile from the Ethiopia border to Dongola with respect to the main river and Sudan's reservoir hydrology without Mandaya.
- Assess the impacts of Mandaya's releases during first filling and the changes in operation of Roseires, Sennar and Merowe on river crossings and safety, navigation and fisheries.
- Assess the impacts of Mandaya's releases and the changes in operation of Roseires, Sennar and Merowe during the operational period on trash loads, river crossings and safety, navigation and fisheries.
- Propose mitigation and enhancement measures.
- Develop an environmental management plan, including any required institutional strengthening.
- Develop an environmental monitoring plan.
- Provide capital and recurrent cost estimates, and an assessment of benefits in monetary terms.

It may be noted that this component is mainly related to Mandaya and NEC operations, as a part of the downstream impacts of Mandaya. The results of this study will feed into the complete ESIA report. Impacts on recession agriculture and river morphology are addressed separately.

If Roseires dam is already raised, or in the process of being raised, the above ESIA should be adapted accordingly.

4.5 REDUCED SEDIMENT TRANSPORT AND REDUCED DREDGING COSTS

As stated in this initial environmental impact assessment report, and in Table 1, one of the benefits of Mandaya storing sediment and reducing sediment transport downstream is expected to be a saving in dredging costs at Roseires.

The benefits of this for NEC require quantifying and incorporating in the Mandaya project economic analysis. These are essentially engineering matters and it is envisaged the summary results of studies by engineers for the technical feasibility study would be included in the Mandaya ESIA report for completeness. It is considered that an ESIA relating to cessation or reduction of dredging in not required.

4.6 REDUCED SEDIMENT TRANSPORT AND RAISED DRY SEASON FLOWS AT IRRIGATION SCHEMES AND WATER SUPPLY TREATMENT WORKS

As stated in this initial environmental impact assessment report, and in Table 1, irrigation schemes are expected to benefit from reduced operational and maintenance costs for clearing silt and by increased flows and river levels in the dry season, improving supplies to commanded irrigation areas. Subject to various factors, some existing schemes may be extended, or abandoned or poorly served areas may be brought back into production. It is envisaged that an irrigation engineering study will pursue this and estimate the benefits.

This study should also estimate cost savings at water treatment works and pumping stations.

At water treatment works, cost savings may be expected from reduced pumping energy costs because of regulated higher water levels in the longer dry season offsetting regulated lower levels in the shorter annual flood season. Reduced water treatment costs may be expected because of reduced sediment loads.

The benefits require quantifying and incorporating in the Mandaya project economic analysis. These are essentially engineering matters and it is envisaged the summary results of studies by engineers for the technical feasibility study would be included in the Mandaya ESIA report for completeness. An ESIA study is not currently proposed.

It may be noted that farmers with small pumps for irrigation, cost savings may be expected from reduced fuel costs for the same reasons as at water treatment works. However, this is not certain and compensation may be required. This aspect is considered in Section 10 below.

4.7 REDUCED SEDIMENT TRANSPORT AND REDUCED PUMP MAINTENANCE AND REPLACEMENT COSTS

Savings in pump maintenance and replacement costs may accrue from reduced abrasion by sediment. An assessment is required. Again, this is essentially an engineering matter and it is envisaged the summary results of studies by engineers for the technical feasibility study would be included in the Mandaya ESIA report for completeness.

4.8 RIVER MORPHOLOGY STUDY

With retention of most of the sediment load in Mandaya reservoir, the released turbined and spillway water will have greater energy. Changes in river morphology may be expected in the Blue and Main Nile. River training and bank protection works may be expected. A river morphology study is required to assess potential impacts and identify vulnerable locations in order that mitigation works may be proposed and cost estimates produced. The study will require an ESIA component. The objectives of such a study and notes on probable methodology are given below. Following consideration of these in Sudan, Terms of Reference may be developed.

Objectives

1. To assess the potential for channel form changes in the Blue and Main Nile for

    a) the existing hydrological regime (including regulation by Roseires, Sennar and Merowe as operated at the time of study), and

    b) the future hydrological regime with various levels of regulation produced by upstream regulatory storage in Ethiopia and by any associated changes in operation of Roseires, Sennar and Merowe as a result of proposed/assumed conjunctive use.

2. To identify river reaches susceptible to channel form changes where river training and bank protection works may/will be necessary to protect existing or planned engineering works (e.g. bridges, dams, navigation facilities, flood defence works), abstractions (e.g. pumping stations), outfalls (e.g. sewers, irrigation drainage return flows), properties and agricultural land.

3. To provide outline engineering drawings and preliminary cost estimates for river training and bank protection works for the most vulnerable reaches (in 2 above) in the short/medium term (up to 25 years).

4. To assess potential environmental and socio-economic impacts of channel form changes in 1a and 1b without implementation of mitigation measures – the "do nothing" scenario, illustrating the consequences of this, if and where relevant, by reference to Egypt's experience downstream of High Aswan Dam prior to implementing mitigation works.

5. To assess environmental and socio-economic impacts of implementing engineering mitigation works for the most vulnerable reaches (in 3 above) and any non-engineering mitigation works (e.g. compensation for losses) as may be required.

6. To assess what proportion of costs of proposed river protection and other mitigation works such as compensation may be reasonably ascribed to Ethiopian regulatory storage developments.

7. To recommend institutional arrangements for planning, designing, implementing and maintaining mitigation works, monitoring their effectiveness and maintaining surveillance of vulnerable reaches for which no works are carried out but may be required.

Notes on Methodology

To meet these objectives, the study will investigate and record the historical changes in river morphology of the Blue Nile and Main Nile to the extent permitted by documents, photographs and satellite imagery. The hydrological background to these known changes will be investigated. An understanding of the scale of historical changes will be gained, and explanations given for them where possible. Sites of major historical change will be visited in the field and recorded.

Hydraulic geometry parameters shall be determined at regular gauging stations "at a station" and "downstream", following the classic work of researchers such as Leopold, Wolman and Miller[4] (1964), and Morisawa[5]. Fieldwork will be required, particularly at gauging station sites and at other reaches, including those where major riverbank engineering/irrigation/water supply works exist or are planned. Hydraulic geometry parameters will be linked to flood hydrology, including determining bankfull capacity and the role played by sediment transport.

[4] Leopold, Wolman and Miller. 1964. *Fluvial Process in Geomorphology*. W.H. Freeman and Company, San Francisco.
[5] Morisawa, M. 1985. *Rivers: Form and Process,* Longman, London

One or more models is expected to be developed and calibrated to investigate potential changes in channel morphology along Blue and Main Nile. The model will seek to determine the magnitude, duration and frequency of morphological changes at key locations with a series of regulated flow regimes with greatly reduced sediment loads produced by one or more upstream regulatory storages in Ethiopia (Karadobi/Mandaya/Border).

The study will include a social and environmental component. Surveys will be needed to establish stakeholders' opinions on historical and current river morphology changes and an assessment made of past and present winners and losers – the former are those who gained land or other resources, the latter are those who experienced damages and/or lost land and resources as a result of channel morphology changes. The social and environmental study component will carry out works to address objectives 4 and 5. With regard to compensation, the study will address the need for contingency budgets for compensation, bearing in mind that ascribing future adverse changes in morphology to one or more Ethiopian regulatory storages, compared to natural changes or changes brought about by operations in Sudan, will not be crystal clear. Procedures, and technical and administrative mechanisms, for riparian users to make claims for compensation and/or to request additional mitigation works shall be described, noting provisions of Sudanese law which facilitate hearing and justly dealing with such claims. If existing law does not clearly cover claims for compensation (relating to a category which can include damage from river morphology changes), a grievances mechanism shall be developed and made widely known.

The results of the engineering and ESIA study, including cost estimates, would be made available to the main ESIA report for Mandaya.

4.9 REDUCED URBAN AND RELATED PROPERTY FLOODING

Simulations of Mandaya reservoir behaviour and turbined releases and spillway flows have indicated that the annual flood of the Blue Nile and Main Nile will be severely reduced. This appears likely to have major benefits for reducing urban flooding, health problems and related disruption and damages along the Blue and Main Nile, at parts of Khartoum and Dongola in particular. A preliminary estimate of average annual flood damage costs in a rapid assessment study is indicated at close to USD 50 million/year. The estimate did not account for all flood damage aspects. For the Mandaya ESIA, this estimate requires review and updating and including as a benefit in Mandaya's project economics.

It is envisaged that the technical feasibility study will produce a new set of simulated spillway flows at Mandaya and will route these flows downstream and estimate impacts on flood levels at key stations. This will confirm, or otherwise, this multipurpose benefit of Mandaya. This will be the opportunity to review and update the earlier preliminary estimate of average annual flood damage costs of the rapid assessment study.

It is proposed that the summary results of studies by engineers for the technical feasibility study, and benefits, would be included in the Mandaya ESIA report for completeness.

4.10 CONVERSION OF FLOOD RECESSION AGRICULTURE TO PUMPED IRRIGATION

Simulations of Mandaya reservoir behaviour and turbined releases and spillway flows indicate that the annual flood of the Blue Nile and Main Nile will be severely reduced. The annual flood supports life along the river through the desert to Lake Nasser/Nubia, providing overbank water supplies for flood recession agriculture and other vegetation, and re-charging groundwater. It also deposits silt regarded by farmers as an annual dressing of fertilizer. The proposed mitigation for this impact is to convert these areas to pumped irrigation, and for artificial fertilizers to be used as necessary.

A comprehensive study of these issues is required, leading to engineering and agricultural proposals for the mitigation works and estimates of costs and benefits to be ascribed to the Mandaya project.

The study will involve natural resources, irrigation engineering, agronomy and agricultural economics and ESIA. It will include consideration of growing two crops per year, confirming markets for crops and the need for, availability and use of artificial fertilizers. It also requires a hydrological assessment to be made of the Nile's water balance, so that gains or losses to Lake Nasser/Nubia may be estimated for the case a) with normal flooding (no Mandaya) and b) with almost no flooding and the proposed pumped irrigation mitigation works (with Mandaya).

This conversion would need to be implemented before first filling of Mandaya begins in order to prevent hunger and hardship for the affected communities in the first and every subsequent annual flood season when flood flows will be reduced.

The objectives of such a study are given below. Following consideration of these in Sudan, Terms of Reference may be developed.

Objectives

1. To map and assess the riparian areas along the Blue and Main Nile which annually or periodically flood[6] and benefit from floodwater and deposition of silt. These are areas within the riparian alluvial strips either side of the river with and without pumped water supplies. Thus the existing formally irrigated (pumping) areas and the naturally flooded productive areas (gerouf, without pumping, and all other areas with vegetation dependent on Nile water) will be determined[7].

2. To conduct a groundwater resources study to map and determine the yield and recharge characteristics of existing wells, boreholes and mataras in relation to seasonal Nile river water levels. Planning and implementation of an extensive monitoring network is anticipated.

3. To assess the demographic characteristics of the population directly and indirectly dependent on the annual flood.

[6] It is suggested not exceeding the estimated 20- or 25-year flood.
[7] The total area estimated by the Remote Sensing Authority in Khartoum is 3,641 km^2. See Appendix 5.1.

4. To describe the socio-economy of the area in relation to agriculture and related activities, and surface and groundwater supplies, in relation to years when “normal”, “alert”, “critical” and “flooding” conditions have occurred according to the Ministry’s flood warning scheme.

5. On the assumption that flood flows will be significantly reduced in future (and cease completely in many years) and dry season flows will be raised (resulting from one or more regulatory storage developments in Ethiopia), to develop an irrigation plan for the riparian areas along the Blue and Main Nile. The plan layout shall recognise existing irrigated areas, accommodate potential irrigation areas already planned by the Ministry and ensure that all areas historically and beneficially flooded up to the “critical”/”flooding” threshold (but not in excess of this) are commanded by irrigation works in the irrigation plan. It is noted that water distribution shall include all areas which have benefited from flooding historically, including wetland and other areas which are not cultivated.

6. To determine and provide contingency plans for pumped abstractions from low Nile river levels for several years during the first filling of a major storage works on Abbay river in Ethiopia. It may be assumed that flows will be more than sufficient to meet water demands along the Blue and Main Nile in terms of flow rates but the distance from the river bank to the river water, and the pumping lift, will be greater in these early years.

7. To make proposals for soil, crop and animal husbandry practices and water supplies for the plan layout that will both ensure sustainability, at least maintain and preferably improve farmers’ incomes and be culturally acceptable to local communities in the winter season following the normal flood season.

8. To make proposals for soil, second cropping and animal husbandry practices and water supplies for the plan layout which will both ensure sustainability, add to farmers’ incomes and be culturally acceptable to local communities in the low flow season (when regulated Nile flows will be available).

9. To assess markets for all crops, including proposed second crops.

10. To assess/confirm labour availability for both seasons’ cropping and farmers’ willingness and acceptance of proposed irrigation in the first and second cropping seasons.

11. To estimate the capital and recurrent annual costs of the plan to convert all favourable areas (not already irrigated) to irrigation.

12. To assess farmers’ expected incomes with the proposed irrigation plan for the winter and summer seasons of cropping and to demonstrate farmers’ ability to pay for irrigation scheme maintenance, pump maintenance and running costs and crop inputs, with and without artificial fertilizers, cultivation and hired labour.

13. In cases of farmers' inability to pay for all assumed cost components and recover these from production, to propose a cooperative mechanism to assist farmers and ensure that farmers restore their incomes and preferably increase them.

14. To ensure that the plan will maintain date production.

15. To ensure that the plan will obviate the need for famine relief and the services of the World Food Program and other agencies in all foreseeable circumstances.

16. To ensure that the resident and itinerant pastoralist population and livestock served by water supplies from mataras, including mataras which are located many kilometres from the desert edge of the alluvial belt and which are believed to be supplied by the Nile, are supplied by the plan, or otherwise compensated.

17. To quantify the monthly and annual water abstractions from regulated Nile flows; to estimate any return flows, and the monthly and annual consumptive use. These abstractions shall be quantified for all reaches between calibrated Nile gauging stations, and for the reach between Dongola and Lake Nasser/Nubia. Where level only gauging stations exist, an assessment shall be made of their suitability for flow calibration and recommendations made for their calibration accordingly.

18. To propose a practical system for measuring all abstractions, including abstractions for existing irrigation, and for records to be collated, quality controlled and archived.

19. To estimate components of the Blue Nile's and Main Nile's water balance for conditions prior to and after conversion of flood recession agriculture to irrigation.

20. To determine the net impact of the plan on inflows to Lake Nasser/Nubia.

21. To assess the net impact of the plan on water allocations in the Nile Waters Treaty (1959).

The studies to meet these objectives will probably require at least two phases. Topographical mapping at suitable scales, and planning and implementation of the monitoring network for groundwater and adjacent Nile river levels, will be required in the first phase. A social and environmental component will be required from the outset.

The Mandaya project concept, though not studied in detail, is one which may be welcomed in principle because it avoids urban and property flooding in most years, and provides guaranteed water supplies throughout the year to enable two crops to be cultivated each year. Nevertheless, these and other advantages, and adverse impacts, need to be thoroughly presented and discussed with residents along the Blue and Main Nile at an early stage, preferably before any pre-feasibility or feasibility study begins, and throughout ensuing studies.

Along with Lake Nasser/Nubia and Aswan studies, mitigation measures for loss of the annual flood in Sudan, and their cultural acceptability, may be viewed as critical to the Mandaya and/or other storage projects on Abbay river.

4.11 FIRST FILLING AND RIVER REGULATION IMPACTS ON LAKE NASSER/NUBIA

Detailed studies are required of Mandaya's first filling and river regulation impacts on Lake Nasser/Nubia in Egypt and the changes in operations at Aswan to accommodate, mitigate and benefit from Mandaya regulation.

The study of this component (No. 11 in Table 1), like components 2 to 10, will follow the Blue Nile optimisation study.

When the proposed optimisation study has optimised the overall design of the Blue Nile hydropower cascade, within certain ranges, the size of reservoirs, installed capacities, operation strategy, schedule of commissioning, and the filling strategy will be generally determined.

In the feasibility study which follows, the ESIA will re-address the overall impacts at Lake Nasser/Nubia during first filling and the operational period. Thus the components of 1 and 11 will be similar. However, in the ESIA for the feasibility study, the proposed project dimensions and downstream release regimes will be better known and impacts may be assessed more precisely.

Also in the feasibility study, the net water gains (or losses) resulting from converting flood recession agriculture to irrigation in Sudan will be estimated and these may be accounted for in simulation modelling.

For completeness, a first draft of the scope of work is given below[8].

4.11.1 Data

1. Describe the main features of the simulation model used for Mandaya reservoir behaviour and the Nile system as far downstream as Dongola, and the adopted simulation model of Lake Nasser. Describe the modelled network, showing tributaries, reservoirs, river gauging station locations and reaches with nodes for consumptive use abstractions for irrigation and public water supplies. Describe the time step of each model (the upstream model may be 10 days, the Lake Nasser model monthly)

2. Describe the geometric and flow characteristics of the reservoir, spillway(s), sluice gates, power station, low level and mid level outlets (as appropriate) at Mandaya, Roseires, Sennar, Merowe and Aswan dams. The elevation/storage/area relationships of reservoirs shall be presented for a) original conditions when first commissioned, b) according to the most recent survey, and c) for the estimated situation in year 2025 (allowing for additional sedimentation before 2025). Characteristics of raised Roseires shall be adopted for 2025 (assuming raising has occurred) and characteristics of any

[8] The scope of work for the Lake Nasser/Nubia part of the Blue Nile optimisation study may be similar but the number of simulation runs for the earlier optimisation study may be one or two orders of magnitude greater.

additional dam on the Main Nile shall be included if very firm proposals exist for it).

3. Present and describe flow records to be adopted for the models, including all calibration gaugings and stage/discharge relationships used in their derivation.

4. Present and describe consumptive use irrigation and public water supply abstractions from the river (and reservoirs where applicable), and evaporation from reservoirs, for the length of flow records adopted, giving data sources.

5. Present naturalised flow records by adjusting gauged records for consumptive use abstractions, changes in storage and reservoir evaporation from beginning to end of flow records.

6. Present and describe data gaps and the basis for infilling naturalised flow records, and present the complete naturalised flow data sets to be employed in the simulation studies.

7. Present and describe 10 day/monthly net evaporation rates, either as invariable rates or as times series for the length of flow records. For Lake Nasser, and elsewhere if applicable, also present and justify any variations of evaporation rates which may be adopted for low reservoir levels.

8. Present and describe the basis for adopting reservoir basin seepage (to groundwater and/or dam site leakage) if not assumed zero or insignificant.

9. Present and describe the basis for adopting reservoir bank storage for rising and falling levels if not assumed zero or insignificant.

10. Present and describe estimated 10 day/monthly consumptive use irrigation and public water supply abstractions from the river (and reservoirs where applicable) for years 2025, 2035, 2045 and 2055 where these water demands include new abstractions resulting from conversion of flood recession agriculture to pumped irrigation (described in Section 4.10). Water demands for these years excluding the new abstractions resulting from conversion of flood recession agriculture to pumped irrigation shall also be presented.

11. Present and describe a series of 36 10-day flows (or 12 monthly) prescribed flows to be released at Mandaya during the years of first filling to MOL. (More series shall be tested as simulations dictate).

12. Present and describe a series of 36 10-day flows (or 12 monthly) prescribed minimum flows to be released at Mandaya during the years of operation after first filling to MOL. (More series shall be tested as simulations dictate). The intention will be that these flows are called on for about 2% of the time, when Mandaya is stressed in severe drought. These releases, coupled with conjunctive use and drawdown of Roseires in severe drought, should meet water demands downstream. They should protect farmers, including those now relying on regulated flows to replace the annual flood, against water shortfalls.

4.11.2 Calibration Demonstration

1. **Mandaya to Dongola model**. For the period 2000 to 2007, for the storage works existing, the methods of operation used, the power plant availability and efficiencies, and for the consumptive use abstractions, demonstrate that the model can satisfactorily reproduce the gauged flow record at Dongola.

2. Present recorded and simulated monthly flows at Dongola in tabular and graphical forms, and describe agreement/differences in statistical terms.

3. Present recorded and simulated monthly energy outputs at Roseires and Sennar in tabular and graphical forms, and describe agreement/differences in statistical terms and by reference to particular operational anomalies advised by NEC.

4. **Lake Nasser model**. For the periods 1992 to 1997 and 2000 to 2007, using gauged flow records at Dongola, the methods of operation used at Aswan, the power plant availability and efficiencies, and for the consumptive use abstractions downstream of Dongola and from Lake Nasser, demonstrate that the model can satisfactorily reproduce levels of Lake Nasser and the gauged flow record measured at Aswan, 35 km downstream of HAD.

5. Present recorded and simulated Lake Nasser levels and monthly flows at Aswan gauging station in tabular and graphical forms, and describe agreement/differences in statistical terms.

6. Present recorded and simulated monthly energy outputs at Aswan in tabular and graphical forms, and describe agreement/differences in statistical terms and by reference to particular operational anomalies advised by EEHC.

7. For the periods 2000 to 2007, using the simulated flows at Dongola derived in 1 above, and other data used in 4 above, demonstrate the goodness of fit of simulated and recorded levels of Lake Nasser, energy at Aswan and flows at Aswan gauging station.

8. Carry out more calibrations as may be necessary. Draw conclusions about the performance of both models for simulating the Nile system for impact assessment of Mandaya.

4.11.3 First filling simulations

1. Starting with

    - the first year of flow records,
    - prescribed flows to be released at Mandaya during the years of first filling to MOL,
    - elevation/storage/area relationships of reservoirs for 2025,
    - consumptive use water demands for year 2025,

- declared initial storage contents and levels at Sudan's reservoirs (to be decided by Consultant)
- Lake Nasser initial level at 175 masl

simulate the behaviour of Mandaya, Sudan's reservoirs and Lake Nasser. Stop simulation when Mandaya's MOL is attained.

2. Repeat 1 with Lake Nasser initial level at 174 masl , through to 160 masl in steps of 1 m, stopping the simulations when Mandaya's MOL is attained.

3. For all runs in 1 and 2, which are for the periods of first filling only, summarise the duration of first filling, the shortfalls for irrigation and public water supply in Sudan, the minimum water levels at gauging stations along the Blue and Main Nile, the energies generated at Sudan power stations and at Aswan power station, the fall in level of Lake Nasser, and shortfalls in demands downstream of Aswan and the energy required for pumping irrigation and water supplies from Lake Nasser.

4. Repeat 1, 2 and 3 starting with the second year of flow records, varying Lake Nasser initial level through 15 x 1 m steps from 174 masl through to 160 masl, stopping the simulations when Mandaya's MOL is attained.

5. Repeat 4 for the third year of records through to the last year of records (adding the earliest records to the last records in order to provide a sufficiently long data series)

6. The above runs shall be aborted if the Consultant considers the shortfalls in water supplies (but not energy) are unsatisfactory (too many, too severe). In which case, the simulations from 1 to 5 shall be repeated, adopting greater prescribed releases at Mandaya. These releases will be heuristically determined.

7. For the adopted prescribed releases at Mandaya that are considered satisfactory for meeting downstream water demands, present a probability/risk analysis for each of the 15 Lake Nasser starting levels. This will complete the following types of answers.

   If Lake Nasser level is at 175 masl when Mandaya begins filling, the energy generation at Aswan during Mandaya's first filling may range between x and y Gwh/year, with the following probabilities, according to n years of inflow hydrology. According to simulated Lake Nasser levels, the energy required for pumping water supplies from the lake will vary between x and y, with the following probabilities, according to same n years of inflow hydrology.

   Such statements will be possible for Lake Nasser's initial levels from 175 to 160 masl.

   Similarly, the outputs of energy at Sudan's hydropower stations and the mean, maximum and minimum water levels at gauging stations in Sudan may be described.

8. In order to determine the reductions in energy generation in Sudan and at Aswan, and the additional energy requirements for pumping water from Lake Nasser, simulation runs are required “without Mandaya”, and therefore without prescribed downstream releases and without the additional water abstractions relating to conversion of flood recession agriculture to pumped irrigation in Sudan. We may consider these runs as the “base case” for 2025.

9. Comparison of the results of 7 and 8 will provide a basis for assessing the foregone energy generation benefits during Mandaya’s first filling, and the additional energy requirements for pumping from Lake Nasser. These energies may then be costed. Similarly, the fisheries, agricultural and navigation implications of first filling Mandaya may be assessed with the benefit of tabulated and graphical outputs from the Lake Nasser simulation model.

4.11.4 Operational period simulations

1. Starting with

- the first year of flow records,
- prescribed flows to be released at Mandaya during the years of first filling to MOL,
- elevation/storage/area relationships of reservoirs for 2025,
- consumptive use water demands for year 2025,
- declared initial storage contents and levels at Sudan’s reservoirs (to be decided by Consultant)
- Lake Nasser initial level at 175 masl

simulate the behaviour of Mandaya, Sudan’s reservoirs and Lake Nasser until Mandaya’s MOL is attained and let the simulation continue for the length of flow records. However, when MOL is attained at Mandaya, or perhaps 12 months later (the Consultant to determine), the simulation program will trigger a flag. The flag will then discard the first filling prescribed releases and import new prescribed minimum releases at Mandaya. These will be lower than in the first filling period because turbined releases will now be taking place.

2. Continue simulations for the arrays described in 4.11.3 and present similar analyses.

3. Continue with more simulations for the arrays but repeating them with water demands for 2035, 2045 and 2055.

4. In order to determine the additional energy generation in Sudan and the impacts on generation at Aswan, and impacts on energy requirements for pumping water from Lake Nasser, simulation runs are required “without

Mandaya", and therefore without prescribed downstream releases and without the additional water abstractions relating to conversion of flood recession agriculture to pumped irrigation in Sudan. We may consider these runs as the "base cases" for 2025, 2035, 2045 and 2055.

5. Comparison of the results "with Mandaya" and the base cases in 4 "without Mandaya" will provide a basis for assessing the additional energy generation benefits at Mandaya and in the Sudan cascade, and the energy impacts at Aswan and for pumping from Lake Nasser. These energies may then be costed. Similarly, the fisheries, agricultural and navigation implications of operating Mandaya may be assessed with the benefit of tabulated and graphical outputs from the Lake Nasser simulation model.

4.11.5 Related issues

The simulations runs described are potentially numbered in thousands. The need for simulations models to have user options for saving full outputs, printing full outputs, presenting graphs of time series and saving and printing summary outputs is clear. The need for developing meaningful alphanumeric codes for simulation run identifications is also clear.

For the many operation period simulations, with and without Mandaya, for water demands in 2025 through to 2055, all components of reservoir water balances should be capable of being abstracted and presented – to provide confidence in results.

Similarly, all energies generated must be capable of abstraction and presentation in digestible formats. For many operation runs, it will be necessary to output energies at Mandaya, Roseires, Sennar, Merowe and Aswan alongside their outputs "without Mandaya" (when Mandaya generation is zero), showing gains and losses against the base cases.

Apart from using models to determine first filling durations, probabilities and impacts, and operational impacts, they may be run to investigate more "what if …?" questions.

Clearly, the above draft scope of work may be adjusted and expanded to consider first filling sequences of two or three storages on Abbay river and downstream impacts. Work along these lines is envisaged for the Blue Nile optimisation study (Section 4.1). For this, variations may be made to investigate, for example,

- size of reservoirs,
- installed capacities,
- prescribed downstream releases during first filling,
- prescribed downstream releases during operational periods,
- schedule of commissioning

in order to develop a strategy for development. This may or may not rule out development of aggregate storage capacity in the Abbay cascade beyond some determined amount in the foreseeable future. If this is the case, any undeveloped sites may be held in reserve for the very long-term future when reservoir sedimentation is advanced and replacement live storage capacity is required.

ANNEXES ON STUDY FORMATS

Annexes 1, 2 and 3 are adopted from African Development Bank guidelines. They provide direction for preparation of ESIA reports related to project feasibility studies.

ANNEX 1: TYPICAL CONTENTS OF AN ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT

The typical contents of an ESIA Report are presented hereafter. It shall be noted that the presentation of the Report may be adapted depending on the nature and specific requirements of the project.

Executive Summary

This section shall present in a non-technical language a concise summary of the ESIA Report with a particular attention on the processes and procedures used; baseline conditions; the alternatives considered; mitigation/enhancement measures; monitoring program; consultations with stakeholders; capabilities of environmental and social units and actions to strengthen those capacities; and cost implications. This Executive Summary shall be written in English, French and a local language, if necessary for public consultations.

Introduction

The Introduction shall indicate the purpose of the ESIA, present an overview of the proposed project to be assessed, as well as the project's purpose and needs. This section identifies the project sponsor and the consultant assigned to carry out the ESIA. It shall also briefly mention the contents of the ESIA Report and the methods adopted to complete the assessment.

i) Policy, Legal and Administrative Framework

This chapter concerns the policy, legal and administrative framework within which the ESIA is carried out. It presents the relevant environmental and social policies of the Bank and borrowing country, as well as the national legal requirements and related constraints (e.g. practices that may discriminate or exclude any stakeholder group) relevant to the project. It provides information on the environmental requirements of any co-financiers, and identifies relevant international environmental/social agreements to which the country is a signatory.

ii) Project Description and Justification

The first part of this chapter shall describe the proposed project and its geographic, ecological, social, economic and temporal context: project location, various project components, capacity, construction activities, facilities, staffing, working conditions, availability and source of raw materials, production methods, products, schedule of works, land tenure, land use system, potential beneficiaries, affected groups (directly and indirectly), and offsite investments that may be required.

This section shall determine and characterise the anticipated liquid, solid and gaseous discharges from the processes, as well as the sources of nuisance such as noise, odours, visual nuisances, etc. It shall indicate the need for any resettlement plan or vulnerable groups development plan. It shall at least include a map showing the project location and area of influence.

The project justification should be based on combined economic, environmental and social assessments. To this end, this chapter shall describe the current situation in the sector, explain the problems or the needs to be satisfied by the project and present the constraints associated with the project implementation.

iii) Description of the Project Environment

This chapter shall first determine the limits of the study area that shall be defined in order to encompass all project direct and indirect impacts. The description and analysis of the physical, biological and human conditions shall address relevant environmental and social issues within this area, including any changes anticipated before project implementation.

Within the human environment, key issues that shall be considered include population characteristics and trends, revenue disparities, gender differences, health problems, natural resource access and ownership, land use patterns and civil society organisation level. For further information on typical issues to consider in an ESIA, refer to ANNEX 2 of the ESAP.

It shall also address the interrelations between the environmental and social components and the importance (value) that the society and local populations attach to these components, in order to identify the environmental and social components of high value or presenting a particular interest. A particular attention shall be given to the rare, threatened, sensitive or valorised environmental and social components.

The information presented shall be relevant to decisions about project location, design, operations as well as environmental and social management. Maps, figures and tables shall be included in this chapter to better illustrate the various environmental and social components.

iv) Project Alternatives

This part of the ESIA Report consists in analysing the various feasible alternatives of the project, including the "without project" option. It normally comprises two sections. The first section identifies and describes the potential feasible alternatives that would allow to reach the project objectives. The second section presents a comparison of the potential alternatives on the basis of technical, economic, environmental and social criteria, as well as of public views and concerns.

The alternative comparison shall address the proposed project site, technology, design, and operation, in terms of their potential environmental and social impacts and the feasibility of mitigating these impacts. For each of the alternatives, the environmental and social impacts shall be quantified as possible, including their economic values where feasible. The selected alternative shall be the most environmentally and socially sustainable, taking into account the technical and economical feasibility.

v) Potential Impacts and Mitigation/Enhancement Measures

This chapter presents a detailed analysis of beneficial and adverse impacts of various components of the selected project alternative on the physical, biological and human (social, cultural and economic) environments. The methodology of assessment, based on a rigorous scientific method, shall be first presented. Then all environmental and social, direct and indirect, short and long-term, temporary and permanent impacts shall be described and assessed, indicating their importance level and their probability of occurrence. The importance level may be assessed on the basis of the nature, extent, intensity and duration of the impact, as well as on the sensitivity of the concerned environmental and social components and perceptions of the public. Irreversible or unavoidable impacts shall be clearly identified. Cumulative effects shall also be addressed taking into account other projects or actions planned in the study area.

Appropriate mitigation measures shall be identified to prevent, minimise, mitigate or compensate for adverse environmental and/or social impacts. Moreover, enhancement measures shall be developed in order to improve project environmental and social performance. Roles and responsibilities to implement measures shall be clearly defined. The cost of the measures shall be estimated, including the cost for environmental and social capacity building and gender mainstreaming, if necessary. Residual impacts shall be presented.

vi) Environmental Hazard Management

Whenever relevant, this chapter shall describe the security measures and propose a preliminary contingency plan for the construction and operation phases of the project (possible contingency situations, major actions to properly react to accidents, responsibilities and means of communications).

For projects that may cause major technological accidents whose consequences may exceed the project site, the ESIA shall include an analysis of the technological accident risk: identification of hazard and potential consequences, estimation of the consequences' magnitude and frequency, and risk estimation and evaluation.

vii) Environmental and Social Monitoring Program

The first section of this chapter shall describe the surveillance measures aiming at ensuring that the proposed mitigation and enhancement measures are effectively implemented during the implementation phase. The second section concerns the environmental and social monitoring activities designed to measure and evaluate the project impacts on some key environmental and social components of concern and to implement remedial measures, if necessary. Indicators, roles and responsibilities shall be clearly defined. The cost of the program shall be estimated, including the cost for environmental and social capacity building if necessary.

viii) Public Consultations

This chapter shall summarise the actions undertaken to consult the groups affected by the project, as well as other concerned key stakeholders including Civil Society Organisations. The detailed record of the consultation meetings shall be presented in annex to the ESIA Report.

ix) Conclusion

The Conclusion shall specify the environmental and social acceptability of the project, taking into account the impacts and measures identified during the assessment process. It shall also identify any other condition or external requirement for ensuring the success of the project.

x) Annexes

List of the professionals and organisations having contributed to the preparation of the ESIA Report.

List of consulted documents, including project-related reports.

Baseline data referred to in the Report.

Record of consultation meetings with primary and secondary stakeholders.

ANNEX 2: TYPICAL ENVIRONMENTAL AND SOCIAL COMPONENTS TO CONSIDER IN ESIA STUDY

In order to comply with the Bank's requirements, environmental and social assessment studies shall address key crosscutting issues. While assessment contents depend on the nature and scope of the project, plan or program, there are typical environmental and social components in the human and natural environments that shall be considered. The following components may not require to be thoroughly analyzed in ESA studies, but their importance and significance in relation to the nature and scope of the considered project, plan or program shall at least be assessed.

HUMAN ENVIRONMENT

The components to consider in the human environment include the elements and characteristics of the social, cultural and economic environments as well as infrastructures and services and land use patterns in the project area and its zone of influence.

Social Environment

Population

- Demographic situation : population size, age and sex composition, geographic distribution, density, ethnic groups, literacy and education, languages, etc.;
- Demographic trends (fertility, birth and mortality rates; growth, forecast, etc.) and pressures/problems associated with demographic trends;
- Characteristics of poor people and other vulnerable groups: who they are, where they live, employability level, economic activities, access to productive factors, etc.;
- Migration patterns (internal and trans-border) and problems associated with migration (male migration, rural depopulation, urbanisation, refugees, ethnic conflicts, etc.).

Gender

- Gender perspective in legal and policy framework (marriage codes and law, inheritance laws, property law, labour law, immigration laws, education and health policy, agricultural and rural development policy, economic policy with regard to gender budgeting; etc.);
- Socio-cultural norms regarding the gender division of labour, rights, and responsibilities, access to and control over resources;
- Participation in decision making at all levels, family, community and national;

- Existence and capacity of Gender/Women's' machinery;
- Existence and capacity of CSOs and women's organizations;
- Types of developmental programmes and projects targeting women and key government agency and donors.

Health

- HIV/AIDS epidemiological situation, especially among the 15-24 and 25-34 age groups;
- Malnutrition status, socio-economic characteristics of malnourished people, initiatives targeting nutritional security;
- Communicable diseases (acute respiratory infection, diarrhoea, cholera, malaria, sexually transmitted diseases, etc.): frequency, importance per age group and sex, major causes, etc.;
- Non-communicable diseases (lung diseases, cancers, heart diseases, mental problems, poisoning, etc.): frequency, importance per age group and sex, major causes, etc.;
- Tropical diseases (yellow fever, dracunculosis, onchocerciasis, etc.): frequency, importance per age group and sex, major causes, etc.;
- Injuries and violent assaults, particularly against women, youth, elderly and other vulnerable groups;
- Health and safety at work (work related injuries, contamination associated with pesticide or fertilizer use, existing control programs and regulations, etc.);
- Environmental health issues (traffic accidents, air pollution, sanitation, water supply contamination, etc.): frequency, importance per age group and sex, major causes, etc.;
- Mortality (particularly maternal, infantile (under 1) and among children (under 5)), morbidity and disability;
- Hygiene and health awareness.

Civil Society

- Composition and size of the civil society (local, regional, national and international CSOs active in the study area): community-based organisations, non-governmental organizations, professional associations, interest groups, women groups, religious groups, private sector associations, etc.;
- Key decision makers at the local and regional levels;

- Dynamism of CSOs in the study area : spontaneous establishment of CSOs (no government or donor funding), CSO survival when external funding decreases, level of participation, success of sponsored projects, etc.;

- Types of developmental projects and programs supported by key CSOs;

- Organisational structures of CSOs and co-operation mechanisms;

- Level of organisation of vulnerable groups (youth, elderly, vulnerable ethnic groups, etc.), poor and women and participation in political and community activities.

<u>Societal Framework</u>

- Country's position on human rights and gender equality and implementation level;

- National laws, policies and programmes aiming to address social problems, particularly population growth pressures and inequalities;

- Governments' priorities in terms of development (social, economic, institutional, etc.), especially in the study area;

- Governmental spending priorities and fund allocated to social sectors (particularly primary education, preventive health care and nutrition programs);

- Governmental institutions and administrative structures;

- Capacities in the environmental and social sectors (including local, regional and national institutions involved in the study area);

- Local and regional political and administrative structures (traditional and modern) and their interrelations.

<u>Cultural Environment</u>

- Cultural heritage : customs and traditions, traditional activities, fundamental values, religious and/or ancestral beliefs, ethnic dialects, leisure, etc.;

- Right and use of natural resources related to cultural practices (religious sacrifices, traditional medication, etc.);

- Cultural factors contributing to excluding some groups from development benefits;

- Major concerns, opinions, interests, and aspirations of local populations;

- Environmental problem awareness, attitude towards nature;

- Architectural, archaeological and landscape heritage, as well as any other heritage element protected or not by laws or regulations.

Economic Environment

- Major economic activities at the local and regional levels and growth trends;
- Relative importance of the formal and informal sectors;
- Primary sector activities in the region: agricultural production (major crops, production system, markets, etc.), animal husbandry (herd composition, migration patterns, major products, etc.), mine production, etc.;
- Secondary sector activities in the region: major industries, particularly transformation industries for primary sector products, etc.;
- Tertiary sector activities in the region: handicrafts, trading, tourism, financial services, etc.;
- Right, use and dependence on renewable natural resources (forests, water, animals, soils) and non-renewable resources (minerals, petroleum, gas) for income generation and self-consumption;
- Inequality patterns (per-capita income among major groups, wealth distribution, rural-urban differences, etc.) and poverty determinants (growth distribution, employment situation, socio-economic constraints, etc.);
- Economic differences between men and women, in particular in the division of labour, income level, property rights, access to and control over resources, employability, etc.;
- Working conditions and employment situation in the region : active population, unemployment rate, incomes and salaries, availability of qualified manpower, etc.

Infrastructures and Services

- Energy sector: diesel access, electric network, affordability, etc.;
- Communications: mail service, radio, telephone network (fixed and mobile), Internet access, television, affordability, etc.;
- Transportation: road and trail network, railways network, waterways network, ports, airports and air transport, transport conditions in different seasons, public and private transportation means, isolation level, affordability, etc.;
- Water supply: facilities (open wells, distribution systems, etc.), ratio per capita, water quality, affordability, etc.;

- Waste and sanitation: management practices, facilities (sewage, disposal site, etc.), affordability, etc.;
- Health services: facilities (hospitals, health centres, drugstores, etc.), inputs (drugs/pharmaceuticals), personnel, ratio per capita, affordability, etc.;
- Education services: facilities (schools, classes, alphabetisation centres, etc.), material, personnel, ratio per capita, affordability, etc.;
- Other services or programmes well implemented in the study area: organized sportive activities, community centres, youth centres, delinquency reduction programmes, etc.;
- Supply of social services to poor people (education, health, water supply, sanitation, food security, etc.);
- Inequalities in service access.

Land Use Patterns

- Current and future uses of land;
- Land carrying capacity;
- Development land policies, plans, zoning, municipal and regional regulations;
- Traditional land use management practices;
- Access to property and land management methods.

NATURAL ENVIRONMENT

The natural environment includes the physical components (climate and air, geology and soils, surface and ground water) and the biological components (ecosystems, vegetation and wildlife) of the study area and its zone of influence.

The biological components refer to existing ecosystems, biological diversity, biotopes or particular habitats, zones to be protected as well as to conservation or protection measures according to the existing legislation. It is important to focus on the degree of biological diversity and endemicity as well as on the scientific or conservation interest of the study area.

Physical Environment

Climate, Weather Conditions and Air Quality

The climatic local and regional conditions (microclimate, mesoclimate or macroclimate), emphasising aspects that may affect the project's activities, such as:

- Radiation;

- Air temperature and rainfall;
- Atmospheric pressure;
- Relative humidity;
- Cloudiness, fog frequency;
- Evaporation and evapotranspiration;
- Wind directions and velocity;
- Air quality including sources of air pollution and nuisance (type, level and causes of air pollution; presence of unpleasant odours and their causes; noise disturbance);
- Particular threats: seasonal atmospheric perturbations and bad weather risks (e.g. sand and dust storms, torrential rain, barometric depression, cyclones, floods, drought, etc.).

Geology, Topography and Soil

At the local and regional levels, emphasising vulnerable or problematic aspects of land and soils, as well as topographic characteristics which may be modified by the project :

- Geological layers, tectonics, rock alteration, mineral resources, etc.;
- Altitude, topography, slope, exposure, etc.;
- Soil and subsoil properties, potential for landslides and erosion, soil permeability and fertility, physico-chemical characteristics (pedogenesis, nutrients, organic matter, etc.);
- Pollution and threat of soil degradation : type, level and causes of soil pollution; threat of soil degradation through natural or human pressures;
- Natural hazard risks: earthquakes, landslides, falling rocks.

Water and Hydrologic Cycle

At the local and regional levels:

- Surface water, riverbanks, lakeshores, wetlands (rivers, lakes, marshes and other stagnant water bodies); hydrographic network; watershed; bathymetry; sedimentation; annual or seasonal water level variations; flow rates; discharges; water physico-chemical characteristics and quality; floodplain; flooding hazards; etc.;

- Groundwater: types of aquifers, location, aquifer depth (potentiometric map), physico-chemical quality of aquifers, recharge patterns, natural recharge, flow directions, underground and ground drainage, vulnerability to pollution, etc.;
- Near-shore waters, coastal shores and seas: physico-chemical characteristics, bathymetry, turbidity, currents, tides, waves and swell, vulnerability of shores and coastal areas to water action, etc.;
- Surface water and groundwater pollution and threat of degradation (from natural or human sources): type, level and causes of water degradation or contamination, perturbations to the hydrologic budget, disturbance in quality, level and natural replenishment of groundwater aquifer.

Biological Environment

Ecosystems

- Types of ecosystems: terrestrial, aquatic, marine and coastal ecosystems and wetlands;
- Ecosystem functions (particularly sensitive at the ecological level);
- Protected areas and sensitive zones (unique and special ecosystems);
- Ecosystem health and ecosystem integrity;
- Types of interactions between the vegetation, wildlife and natural habitats;
- Sustainability and sensitivity (capability to adapt to changes, exploitation methods, etc.);
- Ecosystem pollution and threat of degradation: pollution sources and threats related to natural phenomena and human pressures;
- Local, regional, national or international significance of the ecosystems (scientific, cultural, traditional, leisure, aesthetic, historic or educational);
- Conservation and protection measures and regulations (based on national legislation and regulations, and on international agreements).

Vegetation

- Plant biodiversity: floristic composition; species richness; endemicity; ecological, genetic, cultural, commercial or aesthetic values; degree of threat and nature conservation importance (rare, vulnerable, threatened or protected species), etc.;
- Characteristics of the plant cover: types of communities, presence of sensitive, endangered or unique communities, recovering rate, density, relative abundance, development stages, annual cycles, distribution,

regenerating capacity, role in ecosystem, relationships between vegetation and wildlife, etc.;

- Pollution and threats affecting certain plant species: natural phenomena (e.g. infectious and parasitic diseases) and human pressures (such as the introduction of exotic species, overexploitation, commercialization, use of toxic products with selective or non-selective effects, etc.);
- Particular threats : bush or forest fires;
- Conservation and protection measures and regulations (based on national legislation and regulations, and on international agreements).

Wildlife

- Wildlife biodiversity : wildlife composition, species richness, endemicity, degree of threat and nature conservation importance (rare, vulnerable, threatened or protected species), useful and harmful species, exploitation for human consumption, education and/or tourism, etc.;
- Ecological and behavioural characteristics of animals: absolute and relative abundance, density, biogeographical distribution, particular habitats, home range and territory, movements and migrations, food supply, reproduction, annual cycles, mortality factors, role in ecosystem, relationships between wildlife and vegetation, etc;
- Pollution and threats affecting certain animal species;
- Particular threats: proliferation or invasion of harmful animals (i.e. crickets, rats, etc.);
- Conservation and protection measures and regulations (based on national legislation and regulations, and on international agreements).

Annex 3: Generic Contents of Environmental and Social Management Plan

The purpose of the ESMP is to define and reach an agreement with the project sponsor concerning mitigation/enhancement, monitoring, consultative and institutional strengthening measures to be undertaken during project implementation and operations. The ESMP shall be incorporated in the loan documents signed between the Borrower and the Bank.

The ESMP format shall be flexible to ensure the integration of project specific mitigating, enhancing and monitoring requirements. For instance, the ESMP shall integrate or at least refer to any initiatives, such as resettlement plans, that contribute to enhance the project environmental or social performance but may be prepared separately or as part of the ESIA Report. In addition, the ESMP format shall permit adjustments and revisions to reflect new developments and findings along project implementation and operations.

The ESMP's scope and level of details shall be proportional to the number and complexity of the measures required to ensure the project's environmental and social sustainability.

The following components constitute the minimal contents of an ESMP:

1. General Information

   - Project name
   - Starting date of implementation
   - Project completion date
   - Date of operation
   - Period covered by the plan

2. Objectives of the ESMP

   This section shall specify that the ESMP aims to bring the project into compliance with applicable national environmental and social legal requirements. Other objective of the ESMP is to outline the mitigating/enhancing, monitoring, consultative and institutional measures required to prevent, minimise, mitigate or compensate for adverse environmental and social impacts, or to enhance the project beneficial impacts. It shall also address capacity building requirements to strengthen the Borrower's environmental and social capacities if necessary.

3. Context

   The ESMP shall briefly describe project activities and major environmental and social components that will likely be affected positively or negatively by the project. The context section shall be more detailed. It shall describe and analyze the physical, biological and human conditions prevailing in the project area, highlighting relevant environmental and social issues. Within the human environment, key issues that shall be considered include population characteristics and trends, revenue disparities, gender differences, health problems, natural resource access and ownership, land use patterns and civil society organisation level.

Moreover, the context section shall outline existing interrelations between ecological and social processes. For instance, in the case of a project that would increase water supply, the context section shall identify who are the beneficiaries based on real access to the new facilities, as the elderly, handicapped or poor may not have the capacity to go to and/or to pay for new water supply facilities. Moreover, better water supply tends to reduce health hazard (communicable diseases like diarrhoea) but in some cases it accentuates waste water disposal problems. These interrelations among components shall be mentioned to be taken into account in the impact assessment and the development of mitigation/enhancement measures.

4. Beneficial and Adverse Impacts

This section shall focus on beneficial impacts that can be enhanced to improve the project environmental and social performance as well as on adverse impacts that require mitigation measures to be minimised or compensated. The ESMP shall clearly define the impacts and indicate their level of importance.

5. Enhancement and Mitigation Program

This section shall propose feasible and cost effective measures to address the impacts previously defined, in order to accrue project benefits (enhancement measures) or to reduce potentially adverse environmental and social impacts to acceptable levels (mitigation measures). Each measure shall be described in detail, providing all technical information required for its implementation (design, equipment description and operating procedures, as appropriate).

6. Monitoring Program

A monitoring program aims to ensure that mitigation and enhancement measures are implemented, that they generate intended results and that they are modified, ceased or replaced when inappropriate. Moreover, it allows to assess compliance with national environmental and social policies and standards as well as the donors policies and guidelines. A monitoring program shall include two parts: surveillance and monitoring activities.

Surveillance activities

The surveillance aims to ensure that the proposed mitigation and enhancement measures are effectively implemented during the construction phase.

Monitoring activities

These activities consist in measuring and evaluating the project impacts on some environmental and social components of concern and to implement remedial measures, if necessary.

The program shall define as clearly as possible the indicators to be used to monitor the mitigation and enhancement measures that need to be assessed during project implementation and/or operation. The monitoring program shall also provide technical details on monitoring activities such as methods to be used, sampling locations, frequency of measurements, detection limits, and definition of thresholds that will signal the need for corrective actions.

7. Consultations

The implementation and monitoring of some mitigation or enhancement measures may require that consultative mechanisms be used. In such cases, the ESMP shall first identify for which measures consultations will be undertaken as well as the goals and expected outcomes of these consultations. Then the ESMP shall specify the target groups, appropriate consultative processes, consultation frequency, reporting methods and result disclosure procedures.

8. Complementary Initiatives

The ESMP shall integrate or at least refer to all initiatives that are proposed to improve the project environmental or social performance. Moreover, these complementary initiatives shall be taken into account in determining the responsibilities, institutional arrangements, cost estimates and implementation schedule.

9. Responsibilities and Institutional Arrangements

The implementations of enhancement and mitigation measures as well as the completion of the monitoring program require to clearly establish responsibilities among the various organizations involved in project implementation and operation.

Consequently, the ESMP shall identify the responsibilities of the Bank, the Borrower, the implementing agencies and other stakeholders in applying the ESMP, particularly the monitoring program. In addition, the ESMP shall propose support to the organisations that may have insufficient capacities to fulfil their obligations. This support could be provided through various means including technical assistance, training and/or procurement.

10. Estimated Cost

This section estimates the capital and recurrent cost associated with the various proposed measures (enhancement and mitigation), the monitoring program, consultations, complementary initiatives and institutional arrangements. Although financing for implementing the ESMP shall be part of project financing, it might not always be possible. In such cases, this section shall discuss potential sources of funding.

11. Implementation Schedule and Reporting

The ESMP shall include an implementation schedule taking into account all activities related to the proposed measures (enhancement and mitigation), the monitoring program, consultations, complementary initiatives and institutional arrangements. Moreover, the implementation schedule shall be developed by phases and in co-ordination with the overall project implementation plan.

To ensure early detection of critical environmental and social conditions and to provide information on the mitigation progress and results, reporting deadlines shall be specified in the implementation schedule and reporting procedures shall be presented in this section.